Professional Development for Transformational Technology Integration: An Experimental Study of In-Service Teachers' Self-Perceptions of Technological Pedagogical and Content Knowledge

by

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Abstract

Professional Development for Transformational Technology Integration: An Experimental Study of In-Service Teachers' Self-Perceptions of Technological Pedagogical and Content Knowledge

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The rapid advancement of technology tasks K-12 schools with providing professional development for technology integration. This study sought to address the effectiveness of a TPACK-aligned professional development model in preparing in-service teachers to use technology in ways that transform teaching and learning. Through a single-subject, experimental mixed methods design, this study investigated the relationship between a TPACK-aligned professional development intervention and teacher self-assessment of the following TPACK framework constructs: technological knowledge (TK), technological content knowledge (TCK), technological pedagogical knowledge (TPK), and technological, pedagogical and content knowledge (TPACK) in a rural, K-12 public school district. The following question guided this research: How does a TPACK- aligned professional development model influence teacher self-assessment of TPACK?

The findings of this study contribute to existing literature on the design of professional development for technology integration in technology-rich learning environments and address a gap in the literature on TPACK-aligned, in-service teacher professional development for transformational technology integration.

This Ed.D. Dissertation Committee from The School of Education at Drexel University Certifies that this is the approved version of the following dissertation:

Professional Development for Transformational Technology Integration in K-12 Classrooms: An Experimental Study of In-Service Teachers' Self-Perceptions of Technological Pedagogical and Content Knowledge

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Date

Dedication

To my parents Vivian and Hans Tachau. You taught me that with hard work, I could do anything. Dad, even though you were not here, your love and guidance were felt every step of the way. Thank you both!

To my children, Keegan, Connor and Bailey. Without your love and support, I could not have achieved this. You are and always have been my inspiration for striving to be the best version of myself. Don't ever give up on your dreams!

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I would like to acknowledge Dr. Brian Smith, my committee chair, for his invaluable guidance and input. I would also like to acknowledge Dr. Joy Phillips and Dr. Demetrius Roberts, both of whom served on my committee. I greatly appreciate your time and input along the way.

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I would like to acknowledge my friends and colleagues with whom I work. I have grown so much through our work together over the past 17 years, and I thank you for your encouragement and support along the way.

Finally, I would like to acknowledge my fellow colleagues in each of the three Drexel University cohorts in which I participated. My journey had some unusual bumps along the way that resulted in the need to stop and start the program. I felt welcomed and supported by you each time. Thank you for making those transitions more comfortable.

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Chapter 1: Introduction to the Research

Introduction to The Problem

The 2010 U.S. National Education Technology Plan called for all learners to have "engaging and empowering learning experiences both in and out of school that prepare them to be active, creative, knowledgeable, and ethical participants in our globally networked society" (p. xvi). Federal and state technology plans have created a sense of urgency for school systems to provide students equal access to the internet and digital technology. In response, most public schools today provide at least one computer or mobile device for every five students, and many school systems have invested heavily in one-to-one technology initiatives in which the school supplies one mobile computing device per student (Herold, 2015).

In the fall of 2013, the Los Angeles Unified School District (LAUSD) embarked on what seemed to be the country's most ambitious technology integration plan. Spending $1.3 billion to put iPads into the hands of every student in every school was one of the largest investments in digital technology to date (Lapowsky, 2015). Other school systems across the nation have joined forces with LAUSD; however, many seem to be reevaluating their investments. For example, The Miami-Dade County School District and the Guilford County, North Carolina School System reconsidered their initiatives citing the need to be more cautious and pragmatic (Herold, 2013).

While these initiatives provided one-to-one technology for students in the LAUSD, Miami-Dade County School District and the Guilford, County, North Carolina School System, they have been less than successful in meeting the International Society for Technology Education (ISTE) standards for technology integration. The lack of adequate teacher training is at the forefront of the expressed concerns (Herold, 2013).

Despite the concerns surrounding district one-to-one technology initiatives, many districts are meeting the goal of equal access to technology by putting a mobile computing device into the hands of every student. However, the impact mobile computing devices have had on academic achievement and teacher instruction is far from transformational (Herold, 2015). For example, districts implementing one-to-one technology initiatives do not seem to align their initiatives to the ISTE standards for teachers. The standards seek to reach technology integration that fosters higher-order teaching and learning (International Society for Technology in Education, 2008). The ISTE standards state that teachers should be expected to "engage students in exploring real-world issues and solving authentic problems using digital tools and resources" (International Society for Technology Education Standards, 2008, p. 1). Teachers should "develop technology-enriched learning environments that enable all students to become active participants in setting their own educational goals, managing their own learning, and assessing their own progress" (International Society for Technology Education Standards, 2008, p. 1).

School leaders often fail to meet ISTE standards for teachers when implementing one-to-one technology initiatives because implementation tends to focus primarily on the device itself, the enhancement of the network and the training of teachers to use the technology. This is what has been referred to as "spray and pray" in which school systems "spray" on the technology, and then "pray" that there is an increase in learning (November, 2013). Evidence to support one-to-one technology initiatives as a means to technology integration for learning appears to be minimal. A study on teacher technology use conducted by the National Center for Education Statistics in 2009 found that student technology use in the classroom centered primarily on three activities: preparing written text, conducting Internet research, and learning or practicing basic skills (Gray, Thomas, & Lewis, 2010). Research has identified a need for expanding teachers'

knowledge of educational technology in a way that will transform pedagogical practice from teacher-centered to student-centered, technology-driven instruction (Herold, 2015). Thus, school systems that rush to implement one-to-one technology initiatives are discovering that integrating educational technology for learning is a multi-faceted endeavor and as such, can be an elusive goal.

Statement of the Problem to Be Researched

The problem this study addressed is the lack of technological, pedagogical, and content knowledge (TPACK) in-service teachers demonstrate after experiencing existing professional development for technology integration. Specifically, this study investigated the relationship between a TPACK-aligned professional development intervention and transformative technology integration.

For technology integration to yield desired educational outcomes, professional development is paramount. However, for technology professional development to be effective, it must be designed to address more than just teachers' technological skills (Harris, Mishra, & Koehler, 2009). Professional development for technology integration should enable teachers to make decisions about technology use based on content and pedagogy. However, professional development in one-to-one technology environments is often delivered as a one-size-fits-all model focused on learning to use the device itself. This results in technology use that is an add-on versus the integration of technology with content and pedagogy that transforms teaching and learning (Bebell & O'Dwyer, 2010). Time spent on professional development for technology integration is less than sufficient to meet teachers' needs (Gray, Thomas, & Lewis, 2010). A survey conducted by the National Center for Education Statistics found that sixty-six percent of teachers received eight hours or less of professional development for educational technology

during a twelve-month school year (Gray, Thomas, & Lewis, 2010). Yet, school systems continue to invest heavily in one-to-one technology initiatives without appropriate professional development.

Purpose and Significance of the Problem

The purpose of this study was to provide additional research evidence on whether TPACK-aligned professional development models are effective in preparing in-service teachers to leverage technology in a manner that transforms teaching and learning. This mixed methods study investigated the effects of a TPACK-aligned professional development intervention on in-service teachers' self-perception of knowledge within four of the seven constructs of the TPACK framework: technological knowledge (TK), technological content knowledge (TCK), technological pedagogical knowledge (TPK), and technological pedagogical and content knowledge (TPACK) (Mishra & Koehler, 2006).

The TPACK model provides a framework for educators to consider the inter-relationships between technology, pedagogy and content when integrating technology within a changing classroom environment. This approach requires a specific kind of knowledge called technological pedagogical and content knowledge (TPACK) (Mishra & Koehler, 2009). In order for one-to-one technology initiatives to be successful, educational leaders must provide professional development that results in integrating technology for learning versus the use of technology in isolation.

Research in the area of TPACK has helped educators to understand the inter-relationships between technology, pedagogy, and content (Chai, Koh, & Tsai, 2013; DiBlas, Fiore, Mainett, Vergallo, & Paolini, 2014; Harris, Mishra, & Koehler, 2009). This understanding could provide a foundation for professional learning that results in transformative technology

integration. According to Mishra, Koehler, and Cain (2013), there is no one best way to integrate technology into the curriculum. However, "integration efforts should be creatively designed or structured for particular subject matter ideas in specific classroom contexts" (Koehler, Mishra, & Cain, 2013, p. 14).

Research suggests that technology is not often effectively integrated with instructional activities (Lawless & Pellegrino, 2007). Teachers are faced with the challenge to determine when and how to incorporate technology (Niess, 2011). Emerging expectations for teachers include being adept at a variety of technology-based content delivery, using digital strategies in their work with students, providing student-centered, personalized learning experiences, and using technology to encourage students to engage in learning beyond the four walls of the classroom and the school day (Johnson, Becker, Estrada & Freeman, 2014). Often, pervasive access to technology without adequate professional development results at best in simply digitizing current instructional practice rather than using technology to transform content and pedagogy (November, 2013).

Traditional training models place teachers in decontextualized environments in which they are asked to apply new technologies to situations that are not necessarily applicable to the content they teach (Li, 2010). One-to-one technology initiatives represent a significant investment in terms of technology and infrastructure; however, many districts fail to invest in adequate professional development. Districts that do not plan for consistent, pervasive, and relevant teacher professional development are not likely to see changes in teacher pedagogy or student achievement and engagement (Topper & Lancaster, 2013).

Studies done to determine changes in teacher behavior in response to one-to-one technology in a school have found that teachers rely primarily on the technology for

productivity, word processing, and to assist students in finding answers (Dunleavy, Dextert, & Heinecket, 2007; Garthwait & Weller, 2005; Pennuel, 2006; Storz & Hoffman, 2013). Oliver and Corn (2008) found that students in a two-year middle school study reported that teachers did not alter their pedagogy of direct instruction after the introduction of mobile technology. One account of a one-to-one technology initiative reported a positive impact on student learning, but only in conjunction with a comprehensive professional development program (Lei & Zhao, 2008).

Locally, several districts have embarked on one-to-one technology initiatives. One district, located in Eastern Pennsylvania, is currently in year five of a one-to-one secondary iPad initiative and has provided classroom access to iPad carts for teachers at the elementary level. The district began the initiative as an economic response to the rising cost of replacing and repairing laptop carts. It was more cost-effective for the district to lease the iPads from Apple than it was to continue investing in the laptop carts. The initiative has been successful in increasing access to digital technology for students. However, the professional development plan for teachers has been focused on the technological skills needed to use the iPads. With administrative support, teachers have found ways to collaborate and share iPad successes and challenges; however, the program lacks consistent integration of iPad technology with content and pedagogy. As has been observed through administrative walkthroughs, many staff members are still clinging to traditional pedagogical models. If they can fit the technology into their traditional pedagogy, then they will. If not, they do not.

The literature describes many one-to-one technology initiatives that have been less than successful and have lacked adequate professional development to address technology integration for learning (Dunleavy, Dextert, & Heinecket, 2007; Garthwait & Weller, 2005; Oliver & Corn,

2008; Pennuel, 2006; Storz & Hoffman, 2013). This warranted further research to determine what components constitute a design for professional development that results in transformative technology integration. This research addresses gaps in the literature regarding in-service teacher professional development for transformational technology integration. This research also provides guidance to schools and districts in the design and implementation of professional development plans that result in transformative technology integration.

Research Questions

In establishing this study, the researcher assumed varying levels of teacher self-efficacy for technology use and a need for technology integration that results in the transformation of content and pedagogy. Therefore, this single-subject, experimental mixed methods study was designed to answer one central question: How does a TPACK- aligned professional development model for teachers influence teacher self-assessment of TPACK? The study will answer this question by addressing the following sub questions.

Sub-questions:

1. How does TPACK-aligned professional development influence in-service teachers' self-assessment of technological knowledge (TK)?
2. How does TPACK-aligned professional development influence in-service teachers' self-assessment of technological pedagogical knowledge (TPK)?
3. How does TPACK-aligned professional development influence in-service teachers' self-assessment of technological content knowledge (TCK)?
4. How does TPACK-aligned professional development influence in-service teachers' self-assessment of technological pedagogical and content knowledge (TPACK)?

5. If teacher self-assessment of TPACK has changed at the conclusion of the TPACK-aligned intervention, then what is the perceived context for that change?
6. If teacher self-assessment of TPACK has not changed at the conclusion of the TPACK-aligned intervention, then what is the perceived context for the lack of change?

By answering the central research question and the sub-questions, this mixed methods study provides additional research evidence on the effectiveness of TPACK-aligned professional development in preparing in-service teachers to use technology to transform teaching and learning.

The Conceptual Framework

Researcher Stances and Experiential Base

I assumed a post positivist epistemological position for this study. This stance was appropriate for this study because post positivists rely on antecedent conditions as a basis for knowledge construction (Bloomberg & Volpe). They develop knowledge by careful measurement and observation of the world, thus it is common for a researcher defining knowledge through a post positivist lens to seek to quantify information (Creswell, 2003, Bloomberg & Volpe, 2016). In defining knowledge through a post positivist lens, a researcher often seeks a universal truth that can be identified and tested (Creswell, 2003). Thus, in this single-subject, experimental research study, I sought to understand the relationship between a TPACK-aligned professional development model and teachers' transformative technology integration by measuring changes in individual-level, teacher self-perceived TPACK. A mixed methods approach allowed me to create context for the quantitative data by conducting follow-up interviews designed to gather teachers' perceptions of technology integration after the

intervention and gather qualitative data on any influence the professional development intervention had on teacher pedagogy.

As this study's researcher and a Director of Curriculum and Instruction who plans and designs annual professional development, I must maximize the limited amount of time allocated in the school calendar for teacher professional development. Bi-annual needs assessment surveys repeatedly indicate a need for additional professional development in the area of technology integration. Additionally, a recurring theme in teacher responses to the needs assessment survey is a desire for content-specific, collaborative professional development. As a researcher and an administrator who has participated in administrative walkthroughs at the secondary and elementary levels, I have learned that observations provide data to support a need for professional development that results in technology use that is transformative for teaching and learning versus technology that is simply used as a "$1,000 pencil" (November, 2013).

Relationships are paramount to me. I have been an administrator in this district for the past ten years holding various K-12 administrative roles. Prior to that, I was a secondary teacher in the district and a literacy coach. Thus, I have established and maintain close working relationships with a majority of the K-12 staff. This study was driven by the desire to support district faculty members who are participating in the one-to-one technology initiative and ultimately for it to positively impact student learning, thereby supporting the district's investment. It is my hope that this study will enable the district to improve upon the secondary, one-to-one iPad program and potentially expand the current program at the elementary level with an emphasis on technology integration that transforms teaching and learning. Currently, local stakeholders are questioning the value of the investment.

Conceptual Framework

Within this study, three streams of literature emerged to support the researcher's central research question: How does a TPACK-aligned professional development model for teachers influence teacher self-assessment of TPACK? The three streams are technology integration and one-to-one learning environments, educational technology professional development, and measuring teacher technological pedagogical and content knowledge (TPACK).

1. Technology Integration and One-to-One Learning Environments: This stream explores extant approaches to technology integration and barriers to educational outcomes in one-to-one learning environments (Bebell & O'Dwyer, 2010; Cain, 2013; Cox, 2013; Gorder, 2009; Harris, 2008; Harris, Koehler, & Mishra, 2009; Hervey, 2011; Hew & Brush, 2007; Hughes, 2005; Koehler, Mishra, & Cain, 2013; Shapley, Sheehan, Maloney, & Caronikus-Walker, 2010).
2. Educational Technology Professional Development: This literature stream explores the need for improved professional development and the connections between educational professional development and TPACK (Abbitt, 2011; Allan, Erickson, Brookhouse, & Johnson, 2010; Anderson, 2012; Brantly-Dias & Ertmer, 2013; Chai, Koh, & Tsai, 2013; Cox, 2013; Cox, 2008; Harris, 2008; Harris & Hofer, 2011; Harris, Mishra, & Koehler, 2009; Hofer & Grandgenett, 2012; Johnson, Adams Becker, Estrada, & Freeman, 2014; Koehler, Mishra, & Cain, 2013; Lawless & Pellegrino, 2007; Liu, 2013; Mishra & Koehler, 2009; Mishra & Koehler, 2006; Neiss, 2011; Nelson, Christopher, & Mims, 2009; Pierson & Borthwick, 2010; Schulman, 1986; Thomas, Herring, Redmond, & Smaldino, 2013).

3. Measuring Teacher TPACK: This literature stream explores the relationships among the TPACK components and assessment instruments used to assess teachers' technology use (Archambault & Crippen, 2009; Brantley-Dias & Ertmer, 2013; Cavanaugh & Koehler, 2014; Cox & Graham, 2009; Harris, Grandgenett, & Hoefer, 2010; Maroney & Haigh, 2011; Gomez, 2016; Lin, Tsai, & Chai, 2013; Pamuk, Ergun, Cakir, Yilamaz, & Ayas, 2015; Schmidt, Baron, Thompson, Mishra, Koehler, & Schin, 2010).

Figure 1 illustrates the connection of the conceptual framework to the research question and three research streams.

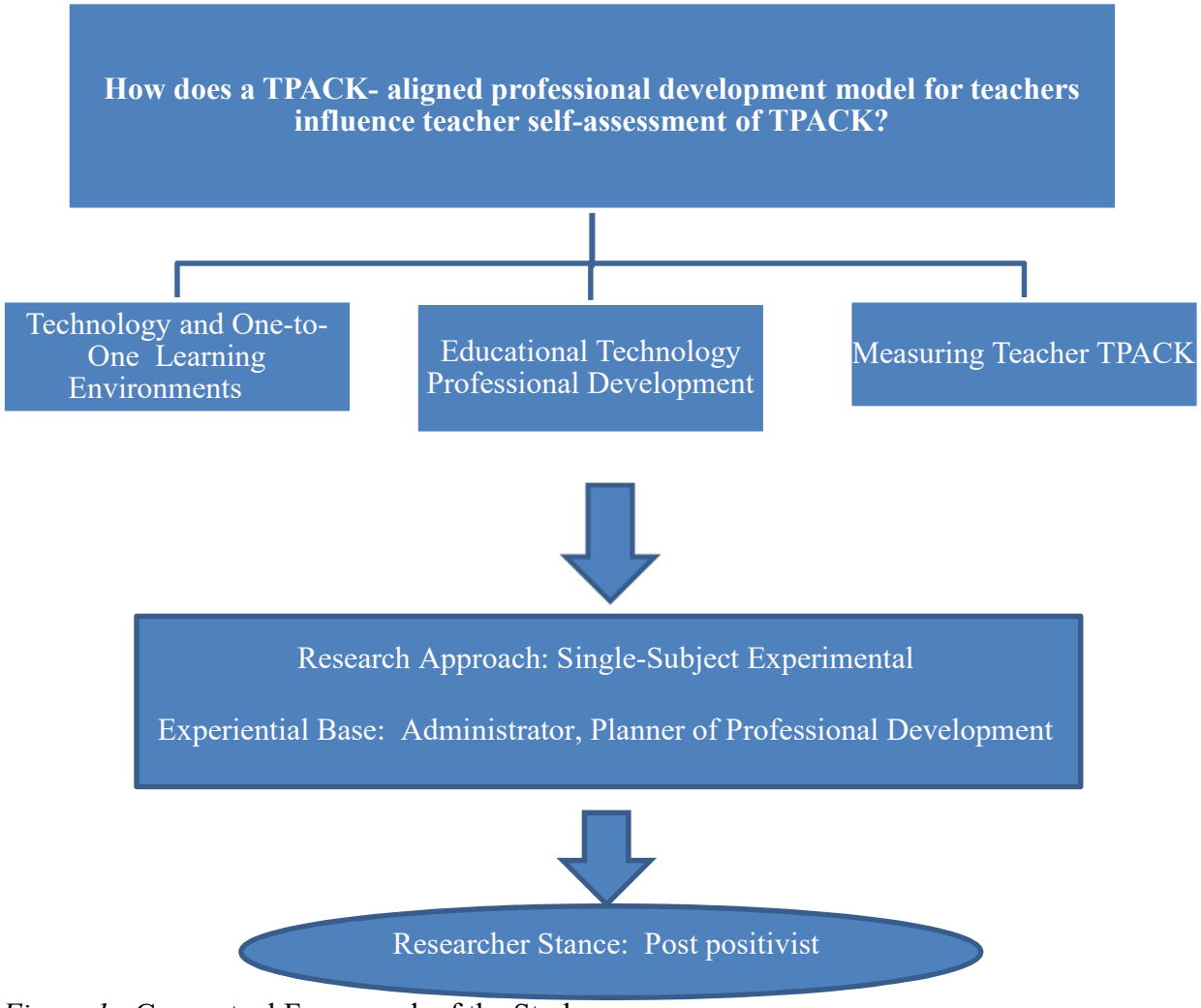

Figure 1: Conceptual Framework of the Study

Definition of Terms

TPACK **-** This acronym is defined as Technological Pedagogical and Content Knowledge and the inter-relationships between the seven constructs. The seven constructs are Technological Knowledge (TK), Content Knowledge (CK), Pedagogical Knowledge (PK), Pedagogical Content Knowledge (PCK), Technological Content Knowledge (TCK), Technological Pedagogical Knowledge (TPK) and Technological Pedagogical Content Knowledge (TPACK) (Misra & Koehler, 2006).

Technology Integration - According to the International Society for Technology in Education (2008), effective technology integration occurs when the technology is an integral part of how the classroom functions. Students are able to select technology tools to find, analyze, synthesize and present information. Higher-order teaching and learning occurs and is aided by the technology.

Educational Technology - The Association for Educational Communications and Technology (AECT) defines Educational Technology as the study and ethical practice of facilitating learning and improving performance by creating, using, and managing appropriate technological processes and resources (Richey, Silber, & Ely, 2008).

One-to-One - The Glossary of Education Reform (2013) defines one-to-one as "programs that provide all students in a school, district, or state with their own laptop, netbook, tablet computer, or other mobile-computing device. One-to-one refers to one computer for every student" (p. 1).

Professional Development **-** As defined by The Glossary of Education Reform (2013), "professional development may be used in reference to a wide variety of specialized training, formal education, or advanced professional learning intended to help administrators, teachers, and other educators improve their professional knowledge, competence, skill, and effectiveness"

(p.1). For the purposes of this study, this term is defined as formal in-service training or continuing education designed to grow the content knowledge, technology knowledge and pedagogical knowledge of teachers.

Assumptions and Limitations

Assumptions. In establishing this study, the researcher assumed varying levels of teacher self-efficacy for technology use and a need for technology integration that results in the transformation of content and pedagogy. Additionally, the researcher assumed varying levels of support on the part of teachers for the one-to-one mobile device initiative at the secondary level. These assumptions were based on the researcher's experience with the one-to-one iPad program as an administrator and professional developer in the district, and as a parent of two students who are participating in the iPad program. These assumptions have influenced this single-subject, experimental, mixed methods study from a post positivist stance that seeks a universal truth that can be identified and tested (Creswell, 2015).

The researcher believes that the professional development provided to teachers charged with the integration of technology via the one-to-one iPad program has been less than adequate in meeting the goal of transforming teaching and learning. The assumption behind this belief is that only thirty-eight hours per school year are allocated to professional development in the district. These thirty-eight hours must meet the professional development needs of K-12 staff for all district initiatives, of which, technology integration is just one. Based on this assumption, the researcher recognizes previous professional development for teachers in the iPad program has not been content driven, nor has it been focused on pedagogy. Rather, the focus has been primarily on how to use the iPad to download specific applications the district has pushed out to teachers and students, and how to download and use Schoology, a learning management system,

with the iPads. There has not been any content-specific professional development for one-to-one mobile device teaching and learning, and there have been minimal opportunities for teachers to collaborate formally.

The researcher assumed, based on her relationships and observations of teachers, that there has been informal teacher collaboration surrounding use of iPads in the classroom. The researcher believed that a mixed methods approach to this study with a single-subject, experimental design would provide quantitative and qualitative data on the impact of a TPACK-aligned professional development intervention on teachers' transformative technology integration. The assumption was that pre- and post-intervention survey data could be analyzed to determine if the TPACK-aligned professional development intervention will improve teacher self-assessment of any of the four TPACK framework constructs that have been connected in the research to transformative technology integration. The researcher also conducted follow-up interviews with the participants after the intervention. It was assumed that the qualitative data and quantitative data would converge to support the data analysis. It was the researcher's hope that this study would inform the design of professional development for technology integration in K-12 teaching and learning environments and address gaps in the literature surrounding in-service teacher professional development for transformational technology integration.

Limitations. There were five limitations to this study. First, participants in the study were not new to one-to-one learning environments in which all students are provided with a mobile device. They received previous professional development designed to increase teacher utilization of the technology. Any results of this study must take into account that the professional development intervention occurred after teachers were provided with four years of professional development opportunities designed to increase teacher utilization of one-to-one

technology in teaching and learning. Secondly, due to the design of the professional development intervention, the sample size was not large enough to apply inferential statistics to determine correlation. Thus, the descriptive statistical results could only suggest a need for further study, with a larger population, to determine correlation. Thirdly, some participants might have been hesitant to be completely honest in their responses to the survey and interview questions because the researcher is also a district administrator.

Fourthly, the sample was dependent upon who was willing to participate in the course. All 196 teachers in the district had the opportunity to participate in the professional development intervention. The intervention was designed as a six-week online, asynchronous graduate course. As is common practice in the district, teachers did not have to pay for the course unless they did not earn a grade of 'B' or better. The researcher chose to include all course participants, upon their agreement, regardless of technology experience, content-area, or grade level. Therefore, the sample selected was a convenience sample because the researcher did not have control over who chose to participate in the intervention. It was the researcher's hope that this manner of identifying participants for the study allowed the data to span a wide variety of subject areas and experience levels on the part of teachers. However, the researcher did not have control over the number of participants in this study or the grade levels and subject areas that they represented. Demographic and teaching assignment data will be included in the data collection. Finally, the researcher acknowledges that there are other, unmeasured variables that could affect change in teacher self-assessment of their TPACK. The results of this study do not take into account any other unmeasured variables that could have affected change in teacher self-assessment of the TPACK framework constructs.

Summary

In summary, the purpose of this study was to identify and understand what constitutes effective professional development for transformative technology integration in one-to-one technology teaching and learning environments. Effective professional development for technology integration can transform teaching and learning. Because so many schools and districts are implementing or planning to implement one-to-one technology initiatives, school leaders need to know whether existent models for professional development are effective in preparing in-service teachers to use technology in ways that transform teaching and learning. Unfortunately, professional development for technology integration in K-12 learning environments is often delivered as a one-size-fits-all model (Harris, 2008). School leaders who implement one-to-one technology initiatives often focus only on technological skills when designing professional development. This results in technology use that is an "add-on" versus the integration of digital tools with content and pedagogy to foster student learning and achievement.

This study provides additional research evidence on whether TPACK-aligned professional development models are effective in preparing in-service teachers to leverage technology in a manner that transforms teaching and learning. The following literature review explores current paradigms for technology integration in one-to-one technology learning environments. The literature review then examines the need for and design of educational technology professional development, and finally it explores measurement tools and the assessment of teachers' TPACK.

Chapter 2: The Literature Review

Introduction to Chapter 2

With advances in 21st century technology, the use of digital technology in K-12 education is rapidly becoming the norm. Federal, state and local initiatives focus on improving the capacity of schools to use technology, training teachers to integrate technology in their classrooms and making technology accessible to all students. Despite such initiatives, integrating technology for learning is a multi-faceted endeavor. School leaders struggle to keep pace with the ever-changing nature of technology. For technology integration that yields desired educational outcomes, professional development is paramount. However, for it to be effective, it should be designed to address more than just teachers' technological skills (Harris, Mishra, & Koehler, 2009).

Research suggests that technology is often not effectively integrated with instructional activities (Lawless & Pellegrino, 2007). Teachers are faced with the challenge of determining when and how to incorporate technology (Niess, 2011). Emerging expectations for teachers include being adept at a variety of technology-based content delivery, using digital strategies in their work with students, providing student-centered learning experiences, and using technology to encourage students to engage in learning beyond the four walls of the classroom and the school day (Johnson, Becker, Estrada & Freeman, 2014). Educational leaders are tasked with providing professional development that results in integrating technology for learning versus the use of technology in isolation.

Educators need to consider the inter-relationships between technology, pedagogy and content when integrating technology within a changing classroom environment. This requires a specific kind of knowledge called technological, pedagogical and content knowledge (TPACK) (Mishra & Koehler, 2009). Research in the area of TPACK has helped educators to understand

these inter-relationships (Chai, Koh, & Tsai, 2013; DiBlas, Fiore, Mainett, Vergallo, & Paolini, 2014; Harris, Mishra, & Koehler, 2009). This understanding provides a foundation for professional learning and technology integration.

When designing professional development for technology integration, TPACK should be a consideration. TPACK is a teacher knowledge framework that builds on Shulman's (1986) construct of pedagogical content knowledge (Koehler, Mishra, & Cain, 2013). Shulman (1986) argued that teachers possess a special type of professional knowledge. This knowledge, pedagogical knowledge, is connected to content knowledge in teacher practice. This is contrary to the historical understanding that sees teacher content knowledge and pedagogical knowledge as separate (Shulman, 1986).

Unfortunately, professional development in K-12, one-to-one technology environments, in which every student is provided with a mobile computing device, is often delivered as a one-size-fits-all model (Harris, 2008). For example, school leaders who implement one-to-one technology initiatives often focus only on technological skills when designing professional development. This results in technology use that is an "add-on" versus the integration of digital tools with content and pedagogy to transform student learning and foster achievement.

Conceptual Framework

Within this study, three streams of literature emerged to support the researcher's central question: How does a TPACK- aligned professional development model for teachers influence teacher self-assessment of TPACK? The three streams include technology integration and one-to-one learning environments, educational technology professional development, and measuring teacher technological pedagogical and content knowledge (TPACK). Figure 2 visually displays the three streams and their connections to the research question.

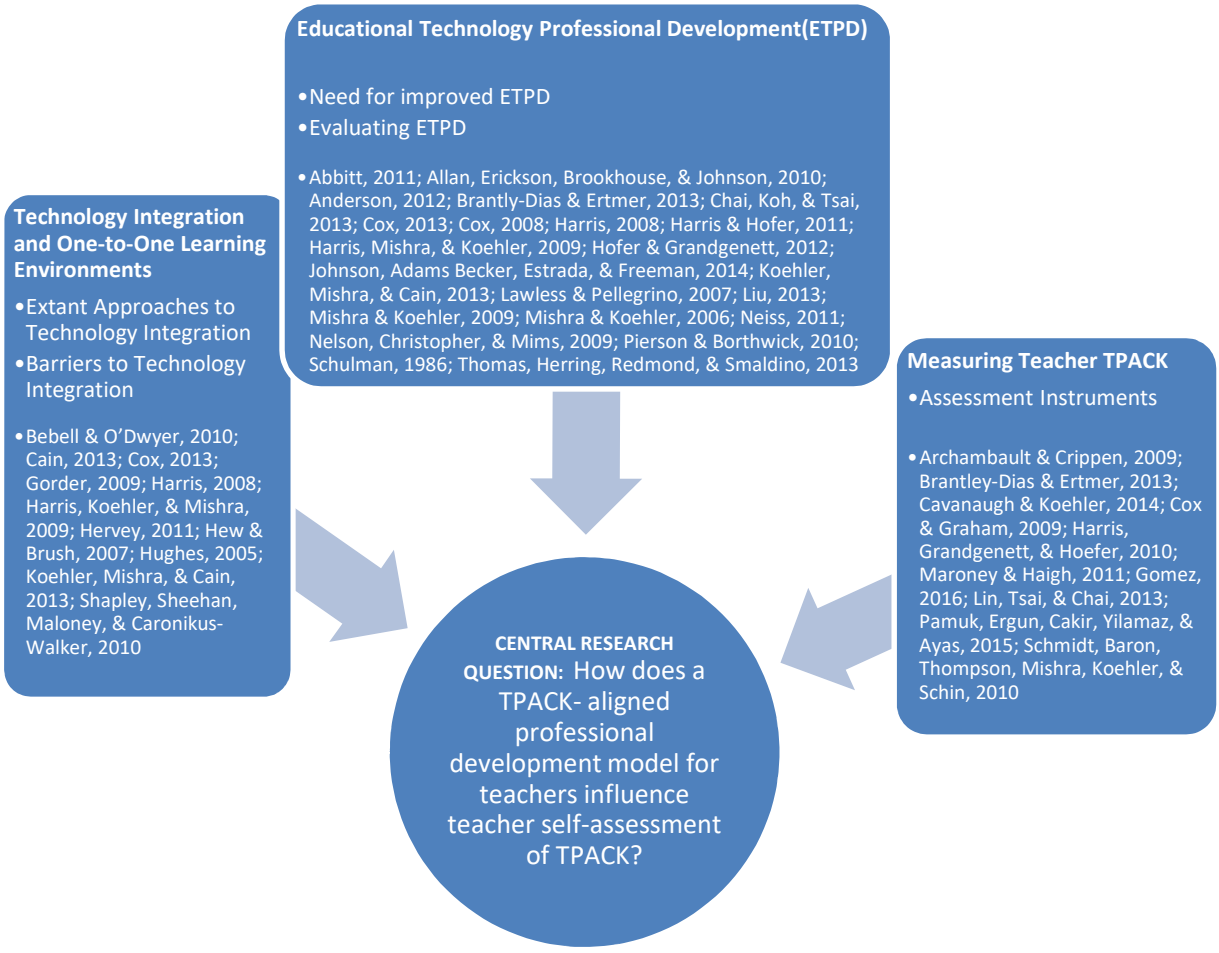

Figure 2 Three Streams of Literature that Address TPACK and Educational ETPD

Literature Review

This literature review summarizes some of the existing research related to educational technology professional development and the potential for educational technology professional development to transform teaching and learning with one-to-one technology; however, there exist gaps in the literature addressing in-service teachers' professional development for technology integration. Much of the literature describes studies that target pre-service teacher professional development for technology integration. The literature review focuses on establishing a need for improved professional development for technology integration, identifying barriers to technology integration, and utilizing the TPACK framework in the design of effective professional development. As part of this research, the literature also serves as data to examine existing assessment instruments for the effective measurement of TPACK in both pre-service and in-service teachers.

Introduction to the Three Streams of Research

This literature review explores current paradigms for technology integration in one-to-one learning environments in which each student is provided with a mobile computing device. This research stream discusses extant approaches to technology integration and barriers to educational outcomes in one-to-one teaching and learning environments. The literature review then examines the need for and design of educational technology professional development. The need for improved professional development and the connections between educational professional development and TPACK are explored in this research stream. Finally, by examining the assessment and measurement of teachers' TPACK, the third research stream explores the relationships among the TPACK components and assessment instruments used to evaluate teachers' technology use. Together, these three streams of research will inform

additional research in TPACK-aligned professional development and its potential to increase teacher TPACK and integration of technology that transforms teaching and learning in the 21st century.

Technology Integration and One-to-One Learning Environments

As the availability of various educational technologies exponentially expands, public education has focused on providing equal access to technology for students. In many public elementary and secondary schools, one-to-one technology initiatives have begun in order to provide such access. Bebell and O'Dwyer (2010) define one-to-one learning or computing as, "the level at which access to technology is available to students and teachers" (p. 6). While providing students and teachers with individual access to laptops, iPads, or other computing devices predicates any impact on student learning and achievement, studies show that K-12 teachers' application of technology reflects a wide variation of practices that often fall short of technology integration (Bebell & O'Dwyer, 2010; Cox, 2013; Harris, Koehler, & Mishra, 2009). Technology integration, as defined by the International Society for Technology in Education (ISTE) is "the ability of students to be able to select technology tools to help them obtain information in a timely manner, analyze and synthesize the information, and present it professionally" (Gorder, 2009).

Extant approaches to technology integration. Teachers play an essential role in the effective implementation of one-to-one mobile device initiatives. Because the responsibility for technology integration often falls to the teacher, it is important to note the power of individual teachers in the success or failure of one-to-one mobile device initiatives (Bebell & O'Dwyer, 2010). Predominant approaches to technology integration include teacher uses of technology for information, communication, efficiency aids and extension devices (Harris, Mishra, & Koehler,

2009). These approaches do not target students' cognitive processes, and therefore are not transformative in nature. This lack of transformative use of technology is a result of how technology integration has been conceptualized and supported (Harris, Mishra, and Koehler, 2009).

Technology integration efforts have historically included software-focused initiatives, technology-based educational reform efforts, structured/standardized professional development workshops, one-size-fits all demonstrations of technology use in lessons and technology-focused education courses (Harris, Mishra, & Koehler, 2009). Research shows that most technology integration efforts lack an intentional connection between instructional strategies, technological skills, and the classroom context or content of study (Hew & Brush, 2007). Koehler, Mishra, and Cain (2013) argue for an approach to technology integration that "treats teaching as an interaction between what teachers know and how they apply this knowledge in the unique circumstances or contexts within their classrooms" (p. 14). Harris, Mishra, and Koehler (2009) purport extant technology integration approaches to be devoid of such considerations as disciplinary knowledge differences and the role context has to play in teaching effectively with technology. Thus, these approaches are of limited utility and significance.

Barriers to technology integration. Barriers to technology integration as represented in the literature span a wide range of contexts. Because technology is rapidly changing, versatile, and opaque, there exist many different challenges in teaching with technology (Koehler, Mishra, & Cain, 2013). In a study done by Hew and Brush (2007), 123 barriers were found from a review of past empirical studies. Hew and Brush (2007) classify these barriers into six main categories: (a) resources, (b) knowledge and skills, (c) institution, (d) attitudes and beliefs, (e) assessment, and (f) subject culture. Bureaucracy, time constraints, past technology integration

failures, external pressures and expectations, time intensiveness and constraints, and inefficiencies were also reported as barriers (Cox, 2013).

A lack of resources is perhaps the most obvious barrier to technology integration. The cost of hardware and software in one-to-one technology environments can prohibit equal access to technology (Gordon, 2009). Teachers also find themselves lacking resources such as time to learn new technology and increased time to plan for its use in the classroom. Gordon (2009) and Hew and Brush (2007) cite technical support as a necessary supportive resource for technology integration. Without adequate resources, there is little opportunity for teachers to integrate technology effectively in the classroom (Hew & Brush, 2007).

Technology integration is dependent upon teacher efficacy, which is defined as "teachers' judgment about their abilities to promote students' learning" (Hoy & Spero, 2005, p. 343). Teacher preparation programs as experienced by many veteran teachers did not provide for the knowledge and skills necessary to integrate today's technology in the classroom. Therefore, teachers often lack the appropriate experience or skills that come with using technologies for teaching and learning (Koehler, Mishra, & Cain, 2013). In a mixed methods study of veteran teachers in one-to-one technology settings, Hervey (2011) found generational challenges, specifically those of "digital natives" versus "digital immigrants" to be a barrier to technology integration. Hew and Brush (2007) describe a lack of technology-supported-pedagogy and skills base as a significant barrier. According to Hughes (2005), technology-supported-pedagogy can be categorized into three functions: (a) replacement, (b) amplification, or (c) transformation. When technology is used as replacement, it serves as different means to the same instructional goal. As amplification, it is used to accomplish tasks more effectively and efficiently (Hew & Brush, 2007). As transformation, technology use should strive to influence students' cognitive

processes and problem-solving activities (Hew & Brush, 2007; Hughes, 2005). Many teachers have only been exposed to technology as replacement, as in the use of an interactive whiteboard to project class notes; or amplification, as in the use of a word processor to revise and edit an assignment. Using technology solely as replacement or amplification places the central focus on the technology rather than student needs and curriculum-based content standards (Harris, Koehler, & Mishra, 2009). Therefore, this lack of knowledge and skills causes teachers to fall short of technology integration.

Leadership, time structures, and school planning are all examples of institutional barriers to technology integration (Hew & Brush, 2007). School-level leadership for one-to-one technology integration can strengthen or weaken the one-to-one program. In a quantitative study of the various factors that come in to play in the implementation of a one-to-one program, Shapley, Sheehan, Maloney, and Caranikus-Walker (2010) found that the extent of core subject teachers' classroom immersion in technology was statistically significant in relationship to teacher perceptions of the school's administrative leadership. Likewise, a lack of time for planning and adequate professional development can inhibit successful technology integration (Bebell & O'Dwyer, 2010).

Planning for technology integration is another barrier. Schools that move toward one-to-one device programs for reasons such as free internet access often neglect to plan beyond acquisition of the technology and thus leave teachers to their own devices as technology integration falls short of success (Hew & Brush, 2007). Of all the strategies for overcoming these barriers to technology integration, effective professional development can have the most impact on the success of a one-to-one device initiative (Harris, 2008; Johnson et al., 2014).

Educational Technology Professional Development

Research indicates that it takes 30 hours of professional development to change teacher practice (Harris, 2008). Often professional development time in U.S. public schools is limited to several days per school year. Contrast this with the Singapore model that offers 100 hours of training per year along with the appropriate funding (Johnson et al., 2014). When it comes to educational technology professional development, Harris (2008) found that 19% of teacher-respondents to a national survey of U.S. K-12 teachers done by CDW-G (a provider of technology products for government organizations such as schools) received no professional development. Additionally, 90% of the respondents participated in fewer than two and a half days of educational technology professional development per year (Harris, 2008). The literature identifies several criteria for high-quality professional development: (a) activities that are longer in duration, (b) access to new and evolving technologies for teaching and learning, (c) teacher engagement in relevant context activities, (d) opportunities for peer collaboration, and (e) connections to a clear vision for student achievement (Lawless & Pellegrino, 2007). Simply having access to technology does not equate to learning, and the technology used in isolation of content and pedagogy is not transformative (Nelson, Christopher, & Mims, 2009).

The need for improved professional development. Studies show teachers who are provided time for participation in professional development activities tend to plan and organize classroom instruction around technology (Gorder, 2009). However, professional development designed for technology integration is typically skill-based and frequently neglects the differentiated contexts of content and pedagogy in which teachers operate (Koehler, Mishra, & Cain, 2013). In order to influence student performance, teachers need to implement new

pedagogical practices that are acquired through professional development (Lawless & Pellegrino, 2007).

Many teachers may utilize technology outside of school for social and personal reasons; however, there is no evidence that technology use outside of school has a positive impact on teachers' integration of technology for learning. In a qualitative study, Cox (2013) examined the technology integration experiences of three teachers in the same school who had at least ten years of teaching experience. Cox (2008) found that there was little correlation between a teacher's use of technology for personal or social purposes and technology integration in the classroom. Participants in the study indicated that professional development was not sufficient to address the differentiated needs of the staff. Cox's (2008) study also supports the claim that technology integration and requisite professional development cannot be distinct from pedagogical and content considerations. Nelson, Christopher, and Mims (2009) posit that teachers need to provide students with opportunities to engage with content, make connections, and form new meanings in order for students to take ownership of their learning and be motivated through effective technological and pedagogical use. Effective professional development for technology integration needs to be more than skill-based in order to achieve this goal.

Evaluating educational technology professional development. The literature shows an absence of evaluation data that speaks to the impact of technological professional development on pedagogical change and student learning (Lawless & Pellegrino, 2007; Pierson & Borthwick, 2010). There is a lack of stated research questions, planned designs and multiple data collection. Existing evaluation of professional development does not meet the standards set by What Works Clearinghouse (Pierson & Borthwick, 2010). The approaches and methods used for evaluating

teacher professional development are largely surveys that seek teachers' opinions as to the effectiveness of the professional development (Lawless & Pellegrino, 2007). Quantitative methods to evaluate professional development and its impact on student learning and pedagogical change are lacking. Pierson and Borthwick (2010) support this claim by stating that data surrounding professional development effectiveness are based on teacher self-report and opinion, and are unrealistically depended on as meaningful facts. A new approach to evaluation for educational technology professional development (ETPD) is proposed:

> Effective and meaningful assessment of ETPD requires that we *design* in-service learning activities that can be measured using methods that are consistent with what we know about teaching and learning; *recognize* teacher and student change as it relates to the larger teaching and learning context; and *view evaluation as an inseparable component of ongoing teacher action.* We therefore offer for consideration an ETPD assessment model that merges three theoretical constructs currently enjoying much note and utility, through which professional development consumers might interpret research findings: (a) technological pedagogical content knowledge (TPACK); (b) organizational learning; and (c) participant research and inquiry. (Pierson & Borthwick, 2010, p. 127)

Thus, Pierson and Borthwick (2010) argue for a re-design of ETPD using the TPACK framework in order to evaluate ETPD in a meaningful, measurable way.

In an attempt to address the lack of literature that evaluates the effectiveness of ETPD, Anderson (2012) conducted a quantitative, pretest-posttest design study. The study addressed the effectiveness of professional development for integrating technology in the curriculum of an urban Iowa middle school. As recommended by Pierson and Borthwick (2010), participants in

this study used a TPACK survey to assess their technological knowledge (TK), technological and pedagogical knowledge (PK) and technological pedagogical and content knowledge (TPACK) (Anderson, 2012). The TPACK framework was also the basis for the professional development provided as the intervention in Anderson's (2012) study. Results suggested a positive correlation between the professional development intervention and the middle school teachers' TPACK in all constructs, thus providing research evidence in support of at least one component of Pierson and Borthwick's (2010) recommended approach to ETPD.

Collaborative and differentiated professional development. Studies have found ETPD that is designed to be collaborative can be very successful in transforming teacher practice. These models have all included ETPD that provides opportunities for teacher collaboration, peer observation, and teacher practice (Allan, Erickson, Brookhouse, & Johnson, 2010; Liu, 2013). A collaborative approach to technology professional development can also help teachers to understand and develop technological, pedagogical and content knowledge (TPACK). Through a study that involved six teachers from two elementary schools in Taiwan, Liu (2013) found that elementary teachers' participation in a technology professional development program that is collaborative and that builds teachers' knowledge of TPACK can increase technology integration and consequently transform pedagogy. Likewise, teachers in Maine who participated in a study designed to examine a collaborative model for TPACK professional development reported positive changes in pedagogy, increased content knowledge, and improved technology skills (Allen et al., 2013). Therefore, one could conclude that potential criteria for measuring effective ETPD are its collaborative nature and its alignment to the TPACK framework.

Other studies have found differentiating a content-based approach to professional development for technology integration to be successful. A study done by Harris and Hofer (2011) focuses on TPACK as used in instructional planning by secondary social studies teachers. Professional development provided to seven social studies teachers included offering teachers access to a variety of learning activities and a menu of possible technologies to pair with each learning activity. After participating in the professional development course, teachers used the technology to enhance their existing pedagogy and made decisions about which technological tools they would use based on the content they were teaching (Harris and Hofer, 2011). Harris, Mishra, and Koehler (2009) present another curriculum-based study of professional development for technology integration. By providing participants with TPACK-based activity types from which to choose while planning instruction, they were able to accommodate differentiated pedagogical and teacher needs (Harris, Mishra, & Koehler, 2009). This approach to ETPD highlighted the need for ETPD to be both flexible and differentiated, thus providing additional criteria for the evaluation of ETPD.

Professional development and TPACK. Technological, pedagogical and content knowledge (TPACK) is presented in the literature as a framework for effective technology integration (Koehler, Mishra, & Cain, 2013; Neiss, 2011). The body of research around TPACK is growing rapidly (Brantley-Dias & Ertmer, 2013). According to the literature, successful technology integration professional development should focus on three components of teacher knowledge found in the TPACK framework: content, pedagogy, and technology (Koehler, Mishra, & Cain, 2013). TPACK has been studied in both the context of pre-service teacher training and in-service professional development.

Thomas, Herring, Redmond, and Smaldino (2013) use leadership and change theory as the basis for their TPACK Leadership Theory. Their research offers leadership methods as a path to advance TPACK into teacher education programs. Other studies have been successful in identifying a need to align in-service teacher professional development with the TPACK framework. Cox (2013) discusses technology integration within a TPACK framework. The study makes the claim that a technology plan cannot be distinct from pedagogical and content considerations. Harris and Hofer (2009), in a study designed to determine how teachers' TPACK informs educators' instructional planning, found that curriculum-based, technology-related instructional planning was successful in changing teacher pedagogy to integrate technology. Both of these studies support the argument for TPACK-aligned professional development for technology integration that transforms teaching and learning.

The theoretical framework. Interest in TPACK has grown to be worldwide as researchers engage in a wide context of studies designed to understand the framework's implications (Koehler, Mishra, & Cain, 2013). Mishra and Koehler (2006) expanded the earlier work of Shulman (1986) which identified pedagogical content knowledge as a specific knowledge type possessed by teachers. Shulman (1986) argues that teaching cannot be reduced to specialized skills in the absence of content knowledge, but rather describes a conception of teaching as one that "must include knowledge of the structures of one's subject, pedagogical knowledge of the general and specific topics of the domain, and specialized curricular knowledge" (p. 13). Mishra and Koehler (2006) extend the pedagogical content knowledge (PCK) framework to include technology as an additional knowledge type. Thus, PCK is extended to technological pedagogical content knowledge (TPACK).

TPACK (Figure 3) can be broken into seven constructs or knowledge types: (a) Technological Knowledge (TK), (b) Pedagogical Knowledge, (c) Content Knowledge, (d) Pedagogical Content Knowledge (e) Technological Pedagogical Knowledge (TPK), (f) Technological Content Knowledge, and (g) Technological Pedagogical Content Knowledge (TPACK). The fluid and flexible interactions between the constructs are what make TPACK effective as a framework for technology integration (Koehler, Mishra, & Cain, 2013). The development of the TPACK framework has allowed teachers and researchers to move beyond viewing technology as an add-on and to see it as a knowledge base connected to content and pedagogy (Chai, Koh, & Tsai, 2013; Koehler, Mishra, & Cain, 2013; Niess, 2011).

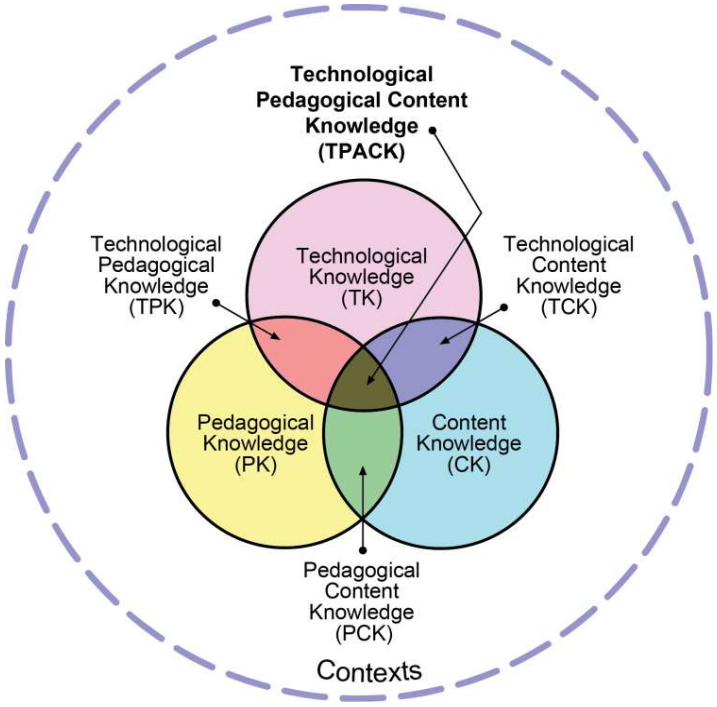

Figure 3 The TPACK Framework**,** Reproduced by permission of the publisher, © 2012 by tpack.org

Teacher perceptions of TPACK. Teacher self-perceptions of TPACK can be helpful in informing the design of professional development. In a study that included 455 in-service teachers in Singapore, Koh, Chai and Tsai (2013) concluded that teachers perceived four direct

paths to TPACK. Technological knowledge (TK), PK, TCK, and TPK all were perceived paths to TPACK, with TCK having the largest perceived effect on teachers' TPACK. The instructional implications of this study suggest that professional development programs should be designed to help teachers develop TK and TPK as well as TCK (Koh, Chai, & Tsai, 2013). In contrast, Brantley-Dias and Ertmer (2013) question the approach to developing TPACK in teachers because the framework does not make a distinction between knowing TPACK and knowing how to use TPACK. Additional research is needed to determine how the TPACK constructs perform in different contexts (Brantley-Dias & Ertmer, 2013).

Pre-service teachers' perceptions of TPACK have been found to influence their self-efficacy beliefs about technology integration (Abbitt, 2011). This indicates that the practice of teaching technology skills in isolation to pre-service teachers, in an attempt to increase technology integration, may not be sufficient to increase the self-efficacy beliefs of pre-service teachers (Abbitt, 2011). Hofer and Grandgenett (2012) found that intentional connections between technology and methods courses in teacher preparation lead to increased technology integration. This emphasizes the inter-relationship between TK and TPK. Therefore, the TPACK framework can also be an important influence when designing pre-service teacher training that results in increased self-efficacy and successful technology integration.

Measuring TPACK in Teachers

Research on effective instruments and techniques for measuring teachers' TPACK appears to be inconclusive. While measurement instruments include surveys, questionnaires, design tasks and teacher observation, there is apparent disagreement in the literature as to what constitutes effective measurement instruments and techniques for assessing teacher TPACK (Brantley-Dias & Ertmer, 2013). Most TPACK measurement instruments rely on teacher self-

reporting, or self-assessment, of the seven TPACK constructs. Harris, Grandgenett, and Hoefer (2010) refer to the challenges presented in accurately assessing teachers' TPACK via self-reporting when discussing limitations in their study. Cavanaugh and Koehler (2014) observe that the measurement of TPACK is "still in its infancy" (p. 146). They suggest the use of contemporary validity theory as a lens through which we can evaluate TPACK measurement instruments. Their analysis found current TPACK measurement instruments each lacking in several types of validity evidence (Cavanaugh & Koehler, 2014). The seven types of validity evidence used in the study of various TPACK measurement instruments are listed in Table 1.

Table 1. Validity Evidence Criteria

Types of Evidence	Description	Examples of Application
1. Content Evidence	The relationship between the instrument's content and what the instrument seeks to measure	Specification of research questions, development of a construct model, writing of items, selection of a scaling model
2. Substantive evidence	Explanation of observed consistencies in the data by reference to a priori theory or hypotheses	Comparing TPACK scores of teachers who have completed TPACK training with those who have not
3. Structural evidence	Confirmation of sub constructs or components in the construct model	Conducting Confirmatory Factor Analysis
4. Generalizability evidence	Individual items are not biased toward particular groups or situations	Testing that each item in a test of TPACK elicits similar responses from males and females with the same overall TPACK level
5. External evidence	Similar results are obtained when different tests are applied to measure the same construct	Comparing findings from observational schedules and document analysis
6. Consequential evidence	Consideration of how results could impact on persons or organizations	Discussing findings with stakeholders

7. **Interpretability evidence**	Communication of the qualitative meaning of scores	Providing a construct map that explains key points on the scale

Source: Cavanaugh & Koehler, 2014

Other literature calls for more precise definitions of the TPACK constructs and clarification of the boundaries between them before TPACK can be measured (Cox & Graham, 2009; Gomez, 2016). Gomez (2016), in a qualitative study of effective technology integration in middle grade social studies classrooms, found data to support a unique development of TPACK in each teacher shaped by the teacher's beliefs and strengths in teaching. The study also suggested a re-thinking of the TPACK framework that would fully allow researchers to capture the TPACK in practice (Gomez, 2016). In contrast, Lin, Tsai, Chai and Lee (2013) found data to confirm the seven-construct TPACK framework in a study that indicated a positive correlation between science teachers' perceived technological content knowledge (TCK) and the other six TPACK constructs. Contradictory findings in the literature may be one reason that few TPACK measurement instruments that align to Pierson and Borthwick's (2010) ETPD assessment model.

Assessment instruments. Of the existing TPACK measurement instruments, it appears that a 47-item Survey of Pre-service Teachers' Knowledge of Teaching and Technology (SPKT), developed by Archambault and Crippen (2009), has been the most generalized TPACK measurement instrument for both pre-service and in-service teachers (Maroney & Haigh, 2011). Maroney and Haigh (2011) developed a questionnaire for measuring in-service teacher TPACK perceptions. The questionnaire included sections for demographics, TPACK Likert scale questions, and three open-response sections. Maroney and Haigh (2011) evaluated the questionnaire using test-retest reliability measures and concluded that it was sound and worth using. Schmidt, Baran, Thompson, Mishra, Koehler, and Shin (2009-2010) conducted a rigorous study designed to create an assessment instrument that can be duplicated for both pre-service and

in-service teachers. The instrument was designed to measure pre-service teachers' self-assessment of their TPACK. Unlike the questionnaire developed by Maroney and Haigh (2011), which was only evaluated using test-retest reliability measures, this survey underwent quantitative analysis in order to establish validity and reliability (Schmidt et al., 2009-2010). The fact that it can be duplicated for both pre-service and in-service teachers increases the utility of the TPACK assessment instrument. Finally, Pamuk, Ergun, Cakir, Yilamaz, and Ayas (2015) conducted a study to explore the relationships among TPACK components in order to develop a TPACK measurement instrument. The tool was designed to measure pre-service teachers' technology integration knowledge and experiences in the TPACK framework. Pamuk et al. (2015) validated the structure of the survey with 147 pre-service teachers using an exploratory factor analysis procedure to determine construct validity and expert judgment to determine content validity. Use of a structural equation model based on TPACK principals to analyze the data supports the claim that the survey is statistically significant (Pamuk et al., 2015). Conclusions drawn from this study indicate that the knowledge bases in the TPACK framework have strong relationships and predictive power of TPACK development in teachers. All three assessment instruments that were designed to measure teacher TPACK have differing claims of reliability and validity. While used exclusively with pre-service teachers, the Pamuk et al. (2015) instrument and the Schmidt et al. (2010) survey offer the most promise for duplication and generalization for use with both pre-service and in-service teachers.

Summary

If successful technology integration is measured by its transformative impact on teaching and learning, then educators are in need of a framework from which to design and evaluate professional development for technology integration. In one-to-one technology environments,

teachers are frequently left to discover the transformative potential of technology on their own. Often, one-to-one device initiatives are declared a success simply because all students and teachers have access to the technology. With the potential for blended learning, project-based activities that incorporate technology, and personalized learning that technology brings, teachers are quickly overwhelmed by technology and its potential pedagogical impact. Differing self-efficacy beliefs about integrating technology make one-size-fits-all professional development models ineffective at best. Likewise, for technology integration to yield desired educational outcomes, professional development should be designed to address more than just teachers' technological skills.

As new technologies become pervasive, the TPACK framework presents an approach to professional development that can provide connections between technology, pedagogy and content knowledge. The use of TPACK to design content-specific, collaborative professional development in one-to-one technology teaching and learning environments has the potential to increase the ability of technology integration to transform teaching and learning. Therefore, further research is needed to determine the design of such professional development. Further research is also necessary to identify effective ways of evaluating TPACK-aligned professional development and its impact on student achievement.

Chapter 3: Research Methodology

Introduction

As schools and districts embark on one-to-one technology initiatives, educational leaders must provide professional development that results in technology use that transforms teaching and learning. Too often, such initiatives result only in technology use in isolation (November, 2013). The problem this study addressed is the lack of technological, pedagogical, and content knowledge (TPACK) in-service teachers may demonstrate after experiencing existing professional development for technology integration. Specifically, this study investigated the relationship between a TPACK-aligned professional development intervention and transformative technology integration. This study is designed to answer one central question: How does a TPACK- aligned professional development model for teachers influence teacher self-assessment of TPACK? This study will answer this question by addressing the following sub-questions.

Sub-questions:

1. How does TPACK-aligned professional development influence in-service teachers' self-assessment of technological knowledge (TK)?
2. How does TPACK-aligned professional development influence in-service teachers' self-assessment of technological pedagogical knowledge (TPK)?
3. How does TPACK-aligned professional development influence in-service teachers' self-assessment of technological content knowledge (TCK)?
4. How does TPACK-aligned professional development influence in-service teachers' self-assessment of technological pedagogical and content knowledge (TPACK)?

5. If teacher self-assessment of TPACK has changed at the conclusion of the TPACK-aligned intervention, then what is the perceived context of that change?
6. If teacher self-assessment of TPACK has not changed at the conclusion of the TPACK-aligned intervention, then what is the perceived context for the lack of change?

In answering the central research question and the sub-questions, this study provided additional research evidence on the effectiveness of existing professional development models for technology integration and the crucial role professional development plays in technology integration that transforms both content and pedagogy. The research design and rationale that follow provide further explanation of how the study could potentially inform the design of professional development for technology integration. The description of the research site and population provide additional context for the study. The research methods and ethical considerations describe the approach and process the researcher undertook in conducting a study that adheres to the ethical considerations for research put forth in *The Belmont Report* (U.S. Department of Health and Human Services, 1979).

Research Design and Rationale

This single-subject, experimental research study sought to measure individual-level, teacher self-perceived TPACK through concrete, quantifiable answers to pre- and post-intervention survey questions. The researcher sought to quantify the pre-and post-survey data to answer the quantitative research questions. A mixed methods approach allowed the researcher to create context for the quantitative data by conducting follow-up interviews designed to investigate further any change in teachers' self-perceptions of TPACK.

Single-subject research involves, "the study of a single individual, a dyad, or a group; observation over a baseline period; and the administration of an intervention…to determine if the

treatment affects the outcome" (Creswell, 2015, p. 317). In a single-subject, mixed methods, experimental design, the individuals participating in the study become their own control group. This study included these key features of quantitative, single-subject, experimental design:

1. *Intervention research.* The use of a quantitative experimental design with a planned intervention.
2. *Intraparticipant research.* Each study participant serves as his or her own control, so all participants are exposed to the intervention.
3. *Baseline phase.* Participants are observed in a baseline condition without the stimulus of intervention.
4. *Intervention phase.* The researcher introduces an intervention condition and again monitors the behavior of the participants. The intervention is considered the independent variable in the study.
5. *Analysis of the data.* The researcher compiles the results as to whether the behavior changed from the baseline phase to the intervention phase. (Creswell, 2015, p. 317)

In this study, the researcher used a TPACK survey instrument replicated from the work of Schmidt, Baran, Thompson, Mishra, Koehler, and Schin (2009-2010) to quantify pre-and post-survey data and answer the quantitative research questions. The five-point Likert-scale TPACK survey instrument was given to participants prior to the professional development intervention and after the professional development intervention. This survey instrument was selected for use in the study based on its development over time and continued use that resulted in proven validity and reliability (Schmidt et al., 2009-2010).

As a site administrator who has participated in walkthroughs at the secondary and elementary levels, the researcher has observed very little technology use that transforms teaching

and learning. Most teachers have leveraged the technology as a replacement tool. For example, most teachers are using iPads for teacher-directed learning activities. The use of the district learning management system allows students to access course content and materials via technology, but teaching and learning is still primarily teacher-centered, even though the curriculum may be digitized. The International Standards for Technology in Education call for students to leverage technology in a manner that empowers them as learners to take an active role in choosing how to use technology to achieve learning goals (ISTE, 2016). The ISTE standards seek to guide teachers in transforming traditional knowledge-based content and pedagogy by engaging students in critical thinking and problem solving. Site observations made by the researcher make it clear that current professional development has not built capacity for teachers to achieve those goals.

Participants in this study were a convenience sample from the 196, K-12 district faculty members. All teachers who enrolled in a six-week, online, asynchronous technology integration professional development course had the opportunity to participate in this study. The researcher anticipated a minimum of ten participants; however, sample sizes in other TPACK-related studies have been much larger. A district teacher, an outside professional development course provider, and the researcher collaboratively designed the professional development course that served as the intervention in this experimental study. Teachers participating in the professional development intervention assessed their technological, pedagogical and content knowledge (TPACK) using a quantitative, 5-point Likert-scale TPACK survey instrument replicated from the work of Schmidt, Baran, Thompson, Mishra, Koehler, and Schin (2009-2010). Teachers participating in the professional development intervention completed the same quantitative survey prior to the professional development intervention and then again after the intervention

occurred in order to identify any changes in teacher self-perception of TPACK. At the conclusion of the professional development intervention, the researcher conducted individual interviews with the participants. The qualitative interview protocol was designed to gather data to provide context for any change, or lack of change, in teacher self-perceptions of technological pedagogical and content knowledge (TPACK).

Site and Population

Population Description

The sampling technique used in this study was convenience sampling. While the researcher agrees that random sampling would have provided the best opportunity to eliminate bias, it was not possible to use random sampling in this study because the researcher had no control over which teachers chose to participate in the professional development course. The course was not mandated. According to Lunenberg and Irby (2008), convenience sampling "involves including in the sample whoever happens to be available at the time" (p. 174).

Table 2. School District "A" Demographics

Site	Grade Levels	No. of Students	No. of Faculty (Professional Staff)
Primary Learning Center	K-2	493	32
Elementary School	3-4	359	36
Intermediate School	5-6	358	32
Junior/Senior High School	7-12	1134	96
School District	K-12	2344	196

Source: School District "A", 2017

The target population of this study was the 196 K-12 teachers in the district (School District "A") where the researcher is employed. The district houses 2344 students and 196 professional staff as seen in Table 2. All teachers in the district were provided with an opportunity to take a six-week online, asynchronous professional development course entitled *Teaching and Learning in the 21st*

Century. The researcher anticipated a minimum of 10 participants in the course. The researcher, an outside provider of educational technology professional development (ETPD), and on-site faculty member collaboratively designed the professional development course that served as the intervention in this research study. The course was designed intentionally to align with the TPACK framework and to ensure opportunities for content-specific collaboration throughout the course (See Appendix A). Learning goals for the professional development course were aligned to the 2016 ISTE Standards for Teachers:

1. To use knowledge of subject matter, pedagogy, and technology to facilitate experiences that advance student learning, creativity, and innovation.
2. To design, develop, and evaluate authentic learning experiences and assessments that incorporate contemporary tools and resources to maximize content learning.
3. To collaborate with peers using digital tools and resources to support student success and innovation.

The researcher also facilitated the professional development intervention. On-site faculty members who have attended the Pennsylvania Keystone Star Technology Conference initiated the development of this course. The researcher, as Director of Curriculum and Instruction, approved the offering of the course and the district superintendent provided his support.

The researcher intentionally made participation in the professional development intervention as convenient as possible. In order to make claims about the generalizability of the results, the design of the study must minimize threats to external validity. One such threat is interaction of selection and treatment. If the convenience sample is relatively small, then it is difficult to generalize beyond the groups in the experiment (Creswell, 2015). For example, the results may not be generalizable to groups that are not represented in the study. Teachers of other

content areas or grade levels, teachers with more or less experience, or teachers who have previously taught in other districts may not be represented if the sample size is too small. As an incentive for participation, the district provided the opportunity for teachers to take the course without having to pay any tuition up front. If they earned a B or better in the course, the district paid the full tuition. Additionally, teachers were able to use the credits earned in this course towards state-mandated continued professional education requirements and to move on step and scale of the current teachers' contract. Finally, the course was offered online without requiring any face-to-face meetings in an effort to mitigate constraints such as lack of childcare when participating in the course. Thus, the researcher anticipated significant interest and participation on the part of the faculty.

Upon registration for the course, the researcher asked each teacher to consider volunteering for the study. All volunteers completed a quantitative survey tool designed to self-assess teacher technological, pedagogical and content knowledge (TPACK). Participants represented several different content areas and grade levels. Collaboration within content areas, and/or grade levels was built into the course design.

Site Description

The participant sample was a convenience sample taken from the population of K-12 teachers in a small school district in Pennsylvania. Located in Eastern Pennsylvania, the district is rural with a very low tax base. The district struggles financially and in the past six years has had to cut teaching positions and implement program changes. The Junior/Senior High School is currently in year five of a one-to-one iPad initiative. Students in grades 7-12 receive iPad minis to use during the school day and at home. Teachers and students in grades K-6 have access to several building iPad carts. Professional development for staff has consisted of primarily skill-

based instruction and collaborative sharing of applications that can be utilized with students and teachers in the classroom. Several teacher leaders have emerged from this initiative and the school administration has built capacity by allowing these teachers to provide staff development.

Secondary teachers are expected to use a learning management system to augment the use of technology in the classroom. Administrative walkthroughs and observations have found that teachers, in general, have had success in using the technology to digitize traditional pedagogy. Students are thrilled with the technology, but teachers struggle with the additional classroom management challenges it presents causing some not to utilize it at all. Parents are questioning the value of the district's investment. The Board of Directors is looking for evidence that iPads in a one-to-one teaching and learning environment can increase student achievement.

At the elementary level, teachers in each of the three elementary buildings have access to iPad carts with twenty-five to thirty iPads per cart. The Primary Learning Center, which houses kindergarten through second grade, has two iPad carts. The Elementary School has four iPad carts that serve grades three and four. The Intermediate School also has four iPad carts shared among grades five and six, with an additional twenty iPads for use by the health teacher, twelve iPads for use by the technology education teacher and eight additional iPads for use by the physical education teacher. The district has tentative plans to expand the one-to-one iPad initiative to the elementary grades over the next several years. According to staff-development survey data, elementary teachers are anxious to integrate the technology in their classrooms, but struggle with less than equal access.

Site Access

As the Director of Curriculum and Instruction for the District, the researcher has access to the site on a daily basis. The researcher obtained a verbal commitment from both the

Junior/Senior High School Principal, Elementary Principals and the District Superintendent for approval and support of the study. The outside provider of ETPD is also supportive of the study. One potential barrier for access may have been the local teachers' union. The researcher anticipated possible concerns regarding confidentiality and the possibility of information used for evaluative purposes. The researcher approached the union president and building representatives with the proposed study to discuss and resolve any concerns or constraints. Written informed consent was obtained from all gatekeepers prior to approaching potential participants and conducting the study.

Research Methods

Description of Each Method Used

Quantitative method. Using a single-subject, experimental, intervention-research design, the researcher collected quantitative data from participating teachers. For this research study, the researcher chose to use a TPACK survey instrument replicated from the work of Schmidt, Baran, Thompson, Mishra, Koehler, and Schin (2009-2010). The instrument was used to identify in-service teacher's TPACK self-assessment and to explore their level of technology use prior to the professional development intervention. The survey was given again after the professional development intervention (see Appendix B).

The researcher chose an existing TPACK survey instrument rather than creating her own because the chosen instrument has proven validity and reliability. Schmidt, Baran, Thompson, Mishra, Koehler, and Schin (2009-2010) first used and validated the survey instrument in a study involving preservice teachers. The primary focus of the study done by Schmidt, et al. (2009-2010) was not necessarily to measure preservice teachers' TPACK, but to administer the survey in order to determine its validity and reliability as an instrument that could be duplicated in both

studies of preservice teachers' TPACK and in-service teachers' TPACK. The survey is based on Shulman's (1986) theoretical framework of Pedagogical Content Knowledge and the work of Mishra and Koehler (2006) that builds on Shulman's (1986) theoretical framework to include technology knowledge resulting in Technological Pedagogical Content Knowledge, or TPACK (Schmidt, et al., 2009-2010).

Schmidt et al.'s (2009-2010) research and development of the survey instrument also builds upon the work of Koehler and Mishra (2005) and Archambault and Crippen (2009) whose studies were designed to "develop a fast, reliable, teacher-rated survey that measures teachers' understanding of each component of the TPACK framework" (Schmidt et al., 2009-2010, p. 128). Schmidt et al.'s (2009-2010) survey extends the work of Koehler and Mishra (2005) and Archambault, and Crippen (2009) by "developing a more robust survey that extends to general contexts, multiple content areas, and multiple approaches of professional development" (p. 128). Their work offers triangulation on survey approaches that work based upon factor analysis, and stands on the premise that the instrument should measure teachers' understanding within different content areas (Schmidt, et al., 2009-2010). Finally, the researcher selected this survey instrument for use in this study based on the research by Schmidt et al. (2009-2010) that indicates the use of the TPACK framework "could potentially have an impact on the type of training and professional development experiences that are designed for both preservice and in-service teachers" (p. 125).

The replicable portion of the survey instrument consists of two sections. Section one is designed to gather demographic information. Section two consists of 46, five-point Likert-scale questions designed to elicit teacher reflection and self-assessment on TPACK and its seven constructs. The seven TPACK constructs are: technological knowledge (TK), content knowledge

(CK), pedagogical knowledge (PK), pedagogical content knowledge (PCK), technological pedagogical knowledge (TPK), technological content knowledge (TCK), and technological pedagogical content knowledge (TPACK) (Misra & Koehler, 2006; Schmidt, et al. 2009-2010). Schmidt, et al. (2009-2010) define the four TPACK constructs this study addressed as follows:

1. *Technological knowledge (TK):* Technological knowledge refers to the knowledge about various technologies, ranging from low-tech technologies such as pencil and paper to digital technologies such as the Internet, digital video, interactive whiteboards, and software programs.
2. *Technological content knowledge (TCK):* Technological content knowledge refers to the knowledge of how technology can create new representations for specific content. It suggests that teachers understand that, by using a specific technology, they can change the way learners practice and understand concepts in a specific content area.
3. *Technological pedagogical knowledge (TPK):* Technological pedagogical knowledge refers to the knowledge of how various technologies can be used in teaching, and to understanding that using technology may change the way teachers teach.
4. *Technological pedagogical content knowledge (TPACK):* Technological pedagogical content knowledge refers to the knowledge required by teachers for integrating technology into their teaching in any content area. Teachers have an intuitive understanding of the complex interplay between the three basic components of knowledge (CK, PK, TK) by teaching content using appropriate pedagogical methods and technologies. (p. 125)

This 46-question, five-point Likert-scale survey was originally designed and validated for a study of pre-service teachers' TPACK. According to Schmidt, et al. (2009), the survey may be

replicated for use with in-service teachers with only minor revisions to the questions designed to gather demographic data. The 46 Likert-scale questions organized around each of the TPACK constructs will remain unchanged for use in this study. The researcher replicated the administration of the original survey by removing categories for each of the questions so that participants will not be predisposed to the constructs when responding to the questions (Schmidt et al., 2009).

Qualitative Method. Using a structured interview protocol, the researcher conducted individual interviews with each of the nine participants at the conclusion of the professional development intervention (See Appendix C). The 15 interview questions were comprised from a listing of guiding questions published by The Practitioner's Guide to TPACK (2012). The Practitioner's Guide to TPACK is an initiative jointly undertaken by the members of the National Technology Leadership Coalition (NTLC). The NTLC was established to address the challenge of helping teachers learn to use technologies in effective ways. The NTLC represents teacher educator associations for core content associations including mathematics education (AMTE), science education (ASTE), social studies (NCSS), English language arts (NCTE), and reading (IRA) (The Practitioner's Guide to TPACK, 2012).

In order to be respective of participants' time, the interviews took place virtually. This was consistent with the design of the professional development intervention, which was an asynchronous online course. During the course, participants had several opportunities to attend virtual class meetings and collaborate via *Zoom*. The researcher anticipated each interview to last no less than 30 minutes and no more than 60 minutes. By conducting the interviews in this format, the researcher hoped to make the participants comfortable and the experience convenient.

Data Analysis Procedures

Quantitative Procedures. The pre- and post-intervention data from the in-service teacher TPACK surveys were collected and organized by TPACK construct. The researcher followed the scoring procedures outlined by the authors of the survey:

> Each item response is scored with a value of 1 assigned to strongly disagree, all the way to 5 for strongly agree. For each construct, the participant's responses are averaged. For example, the 6 questions under TK (Technological Knowledge) are averaged to produce one TK (Technological Knowledge) Score (Schmidt, et al., 2009-2010, Appendix B).

The researcher chose to use version 1.1 of the *Survey of Preservice Teachers' Knowledge of Teaching and Technology* because of its revisions based on research results obtained from previous administrations. The survey instrument has also undergone extensive reliability and validity measures. Schmidt, et al. (2009-2010) used quantitative research methods to establish the validity and reliability of the survey instrument. As seen in Table 3, Schmidt et al. (2009-2010) used Cronbach's alpha reliability technique to assess the TPACK knowledge domain subscale for internal consistency. Schmidt et al. (2009-2010) investigated the construct validity for each TPACK construct subscale using "principal components factor analysis with varimax rotation within each knowledge domain and Kaiser normalization" (p. 130). Factor analysis was run on each of the survey items, and after revisions, each item was exposed to "expert content validity analysis" (Schmidt, et al., 2009-2010, p. 129).

Table 3. Reliability of TPACK Survey Subscale Scores

TPACK Doman	Internal Consistency (alpha)
Technology Knowledge (TK)	.86
Content Knowledge (CK)	
Social Studies	.82
Mathematics	.83
Science	.78
Literacy	.83
Pedagogy Knowledge (PK)	.87
Pedagogical Content Knowledge (PCK)	.87
Technological Pedagogical Knowledge (TPK)	.93
Technological Content Knowledge (TCK)	.86
Technological Pedagogical Content Knowledge	.89

Source: Schmidt et al., 2009 (see Appendix B)

Quantitative data collected from both the pre-intervention survey and the post-intervention survey were analyzed using SPSS software. The researcher did not anticipate the convenience sample to be large enough to suggest the use of inferential statistics. Therefore, descriptive statistics were used to describe, summarize, and compare the pre-intervention quantitative data to the post-intervention quantitative data. Mean scores for each construct in the pre-intervention data and the post-intervention data were compared to identify changes in the TPACK self-assessment for the group and for individual participants. Standard deviation for each mean score was analyzed to determine the variability of the scores around the mean. The researcher used the results of the descriptive statistics analysis to answer the quantitative research questions and to determine what influence, if any, the TPACK-aligned professional development had on participants' self-assessments of TK, TPK, TCK, and TPACK.

Qualitative Data Procedures. The post-intervention interviews were recorded, with permission from the participants. All recorded interviews are being kept in a password-protected file on the researcher's computer for a minimum of one year. The researcher used a third-party

transcription service, Rev.com, to provide word-for-word transcription of each interview in order to explore the data and identify the big ideas in relationship to the qualitative sub-questions:

1. If teacher self-assessment of TPACK has changed at the conclusion of the TPACK-aligned intervention, then what is the perceived context of that change?
2. If teacher self-assessment of TPACK has not changed at the conclusion of the TPACK-aligned intervention, that what is the perceived context for the lack of change?

The interview transcriptions were read and re-read to immerse the researcher fully in the qualitative data. Next, the researcher manually coded the data from each transcript. Applying descriptive coding to the data was the first step towards identifying recurring patterns in the data (Creswell, 2012).

Once the descriptive coding was complete, analytical coding was conducted to inform the purpose of the study. Analytical coding occurs when categories or themes are derived from descriptive coding through interpretation and reflection on the meaning of the data (Merriam & Tisdell, 2016). Qualitative data analysis requires an awareness of and deep familiarity with the data in order to have an open mind to the subtleties of some common threads (Guest, MacQueen, & Namey, 2012). Thus, the researcher repeated this process to revise the coding scheme and look for emerging themes in the qualitative data. A theme is defined as "a phrase or sentence that identifies what a unit of data is about and/or what it means" (Saldana, 2013). Findings were reported and analyzed within context of the qualitative research sub-questions.

Stages of Data Collection

Initial data were collected from the teacher participants prior to the beginning of the professional development intervention. This served as the base-line data for each participant. Teachers completed the TPACK survey instrument one week prior to their participation in the

professional development intervention course. At the conclusion of the course, the researcher asked participants to complete the TPACK survey instrument a second time. Time considerations included having teachers complete the TPACK survey within the same window of time prior to beginning the professional development course. The same considerations applied to the completion of the survey following the professional development course. Individual interviews were conducted with each participant within a week following the conclusion of the intervention. Figure 4 illustrates the timeline for the researcher and participants in this mixed methods study.

Timeline	Researcher	Participants
2 Weeks Prior to the Professional Development Intervention (Week of June 26, 2017)	Participant identification, invitation and selection.	Review guidelines for participation provided by researcher and assurance of confidentiality. Submit documentation of informed consent.
1 Week Prior to the Professional Development Intervention (Week of July 3, 2017)	Provide participants with quantitative TPACK survey for completion.	Complete quantitative TPACK survey.
6 Weeks (July 10-August 18, 2017)	Facilitate the professional development intervention.	Participate in TPACK-aligned professional development course.
Within 1 Week Following the Completion of the Professional Development Course (Week of August 21, 2017)	Provide participants with the quantitative TPACK survey Conduct post-intervention interviews	Complete Quantitative TPACK survey for the second time. Participate in post-intervention interview

Figure 4 Stages of Data Collection

Ethical Considerations

The researcher has completed the Collaborative Institutional Training Initiative (CITI) training for IRB to ensure understanding of ethical considerations when conducting research. There were two ethical considerations in the design of this study. The first relates to the replication of the existing TPACK survey published by Schmidt, et al. (2009). The researcher did

not use other researchers' data collection methods and survey instrument without permission. Upon Drexel University and IRB approval of this study, the researcher followed the procedures outlined in the usage terms of the survey for obtaining permission to replicate the survey for use in this study (Schmidt, et al., 2009). The second ethical consideration addresses confidentiality. The researcher ensured the confidentiality of all participants by assigning each participant a number. While certain demographic information such as grade level and content area taught were gathered, any other identifying factors were eliminated from this study. The researcher followed the process for acquiring IRB approval through Drexel University and submitted form HRB-503 as required for obtaining approval for the study. One anticipated ethical consideration was guaranteeing the anonymity of the study participants. Since the researcher was also an administrator in the district where the study is to be conducted, there may have been concern that any observational data will be used for performance evaluations. In obtaining informed consent (see Appendix D), the researcher was certain to provide each potential participant with all information regarding the research procedures, purposes, risks and benefits and will include language that clearly informs participants of their right to ask questions and/or withdraw from the study at any time. The researcher also clearly communicated all potential benefits of participation in the study. The researcher included language indicating participation in the study will, in no way, provide any data, observational or otherwise, to inform the teacher's performance evaluation for any school year. Overall, the researcher ensured that respect of persons as autonomous agents was included in the informed consent and that the benefits to participating in this study will outweigh any potential negative effects as outlined in *The Belmont Report* (U.S. Department of Health and Human Services, 1976).

Chapter 4: Findings, Results, and Interpretations

Introduction

The purpose of this dissertation study was to provide additional research evidence on whether TPACK-aligned professional development models are effective in preparing in-service teachers to leverage technology in a manner that transforms teaching and learning. Specifically, this mixed methods study investigated the effects of a TPACK-aligned professional development intervention on in-service teachers' self-perception of knowledge within four of the seven constructs of the TPACK framework: technological knowledge (TK), technological content knowledge (TCK), technological pedagogical knowledge (TPK), and technological pedagogical and content knowledge (TPACK) (Mishra & Koehler, 2006).

The 2017 International Society for Technology in Education (ISTE) Standards for Educators call for teachers to approach educational technology integration as both a facilitator and designer of student learning. In so doing, teachers are expected to "foster a culture where students take ownership of their leaning goals and outcomes in both independent and group settings," and "use technology to create, adapt and personalize learning experiences that foster independent learning and accommodate learner differences and needs" (p. 2). Schools and districts often support the purchase of technology such as iPads and laptops for one-to-one device initiatives without designing professional development for teachers that goes beyond how to use the device itself (Harris, Mishra, & Koehler, 2009; Bebell & O'Dweyer, 2010; Gray, Thomas, & Lewis, 2010). Thus, technology integration often results in educators simply digitizing traditional instructional practices (November, 2013). To achieve the transformation described in the standards put forth by ISTE (2017), professional development for technology use cannot be designed in the absence of content and pedagogical considerations.

The TPACK model provides a framework for educators to consider the inter-relationships between technology, pedagogy and content when integrating technology within a changing classroom environment. This approach requires a specific kind of knowledge called technological pedagogical and content knowledge (TPACK) (Mishra & Koehler, 2009). The professional development intervention in this study was designed by the researcher to align with both the TPACK framework and the ISTE (2017) standards. This study was designed to measure participants' self-assessment of TPACK before and after the professional development intervention in order to determine what influence, if any, a TPACK-aligned professional development intervention could have on teachers' TPACK. The study also sought to understand the context in which teacher TPACK was changed.

Research Questions

This study was designed to answer one central question: How does a TPACK- aligned professional development model for teachers influence teacher self-assessment of TPACK? This study will answer this question by addressing the following sub-questions:

1. How does TPACK-aligned professional development influence in-service teachers' self-assessment of technological knowledge (TK)?
2. How does TPACK-aligned professional development influence in-service teachers' self-assessment of technological pedagogical knowledge (TPK)?
3. How does TPACK-aligned professional development influence in-service teachers' self-assessment of technological content knowledge (TCK)?
4. How does TPACK-aligned professional development influence in-service teachers' self-assessment of technological pedagogical and content knowledge (TPACK)?

5. If teacher self-assessment of TPACK has changed at the conclusion of the TPACK-aligned intervention, then what is the perceived context of that change?
6. If teacher self-assessment of TPACK has not changed at the conclusion of the TPACK-aligned intervention, then what is the perceived context for the lack of change?

This study implemented a mixed methods, single-subject, experimental research design to answer these research questions. Quantitative data were derived from a closed-ended, online pre- and post-TPACK survey, and qualitative data was gathered from open-ended, virtual interviews with each of the nine K-12 teachers enrolled in the professional development intervention course. This convenience sample was taken from 196 K-12 teachers currently employed in the public school district in one southeastern county in Pennsylvania. The quantitative and qualitative data were collected during an eight-week period, and the data were analyzed separately.

Findings

This chapter details the qualitative and quantitative findings of this research study designed to identify the effects of a TPACK- aligned professional development model on in-service teacher's self-assessment of TPACK. An overview of the participant demographics are presented first, followed by the quantitative findings as they address each research question. The qualitative findings are then presented and the chapter concludes with the interpretation results after the quantitative data are considered in context of the qualitative data.

This research study implemented a single-subject, experimental, mixed-methods design in which the individuals participating in the study become their own control group (Creswell, 2015). Quantitative data were collected during the baseline phase of the study just prior to the intervention and again after the intervention phase of the study. The qualitative data were

designed to bring context to the quantitative data and were collected only at the conclusion of the professional development intervention (Creswell, 2015).

Data Collection

Data collection was conducted over an eight-week period, beginning on June 26, 2017 and ending on August 25, 2017. The target population of this research study was the faculty of 196 K-12 teachers in the school district where the researcher is employed. The researcher previously identified an estimation of approximately 10 teachers as participants in the study. Only nine teachers of the 196 potential participants from the target population registered for the intervention course entitled *Teaching and Learning in the 21st Century.* All nine faculty members provided consent to participate in this research study. Participation rate in the study was 100% (n=9).

Demographics

Table 4 provides demographic information for all participants. The majority of the participants in this research study were female (n=7, 79%). All but one participant reported being over 32 years of age (n=8, 89%), with one respondent in the 27-32 age span (11%). The demographic portion of the TPACK survey also recorded participant's area of specialization. This was reported as the following: 22% (n=2) in Mathematics, 11% (n=1) in English and Language Arts, 22% (n=2) in Special Education, 11% (n=1) as Instructional Strategist, 22% (n=2) as Elementary K-2 and 11% (n=3) as School Counselor. Of the respondents to the survey, 11% (n=1) reported 6-12 years in teaching, 67% (n=6) reported 13-20 years in teaching, and 22% (n=2) reported over 20 years in teaching. The respondents to the survey represented both secondary and elementary faculty members as well as educational specialists whose in-service

experience spans six to over twenty years in K-12 education. The majority of respondents (n=8) reported having over 13 years of in-service teaching experience (see Table 4).

Table 4
Intervention Course Participant Demographics (n=9)

Demographics	***N***	**%**
Gender		
Male	2	22.22%
Female	7	77.78%
Total	9	100%
Age Range		
27-32 years	1	11.11%
32+ years	8	88.89%
Total	9	100%
Area of Specialization		
Mathematics	2	22.22%
English and Language Arts	1	11.11%
Special Education	2	22.22%
Instructional Strategist	1	11.11%
Elementary K-2	2	22.22%
School Counselor	1	11.11%
Total	9	100%
Years In Teaching		
6-12 years	1	11.11%
13-20 years	6	66.67%
20+ years	2	22.22%
Total	9	100%

Data Analysis

A single-subject, experimental, intervention-research design was utilized to complete this research study. Both quantitative and qualitative data were collected from the same nine participants. This study included the following key features of quantitative, single-subject, experimental design: intervention research, intraparticipant research, baseline phase, and intervention phase (Creswell, 2015). In order for this study to qualify as intervention research, there had to be a planned intervention that would take place during the intervention phase of this study. *Teaching and Learning in the 21st Century* was the professional development course

designed and taught by the researcher to serve as the intervention in this study. The researcher designed the course to be a six-week, asynchronous online course that aligned to the TPACK framework. The course was comprised of six, one-week modules. The first module introduced the course and provided an overview of the TPACK framework. The second module focused on Web 2.0 tools that support student creativity and innovation. The third module provided participants with an overview of blended learning and blogging as a blended learning tool. In the fourth module, participants were asked to explore ways in which personalized learning could transform pedagogy in the 21st century classroom. Module five provided an in-depth look at project-based learning and teachers participated in a live Twitter chat. Finally, module six asked participants to synthesize new learning by submitting a revised unit plan that integrates technology in a manner that transforms teaching and learning. A common rubric was used to evaluate each unit revision (see Appendix E). Teachers were provided with ongoing opportunities throughout the course to collaborate virtually with participants who taught like or similar content or age levels and to reflect on their coursework through the lens of the TPACK framework.

The baseline phase of this study was one week prior to the beginning of the professional development intervention course. During this week, participants were asked to complete the TPACK survey replicated from the work of Schmidt, Baran, Thompson, Mishra, Koehler, and Schin (2009-2010). The survey was used prior to course participation and immediately following the conclusion of the course. The design of this intraparticipant research study required each participant to serve as his or her own control, so all participants were exposed to the professional development intervention (Creswell, 2015). A structured interview protocol was

utilized to conduct individual interviews with each participant at the conclusion of the professional development intervention.

The data from the pre- and post-TPACK surveys and the data from the individual participant interviews were analyzed separately. The final analysis brought both sets of data together to provide further context for any changes in the pre- and post-TPACK survey data. This analysis is presented in the results and interpretations section in order to answer the research questions posed in this study.

Quantitative data. The TPACK survey was administered to all nine participants during the baseline phase of this research study and again at the conclusion of the professional development intervention. Each participant responded to a 46-question, five-point Likert scale design organized around each of the TPACK framework constructs: technological knowledge (TK), pedagogical knowledge (PK), content knowledge (CK), pedagogical content knowledge (PCK), technological pedagogical knowledge (TPK), technological content knowledge (TCK) and technological pedagogical and content knowledge (TPACK). In addition to demographic data, survey participants were asked to reflect and self-assess on each of the seven TPACK constructs. Participants responded on a five-point Likert scale ranging from "strongly disagree" (1) to "strongly agree" (5). Although the researcher only utilized the survey data collected for four of the seven TPACK framework constructs (TK, TCK, TPK, and TPACK), she did not wish to alter the survey significantly. The researcher did so in an effort to maintain the established validity of the survey that was replicated for use in this study. The categories for each of the questions were removed so that participants were not predisposed to the constructs with the TPACK framework when responding to the questions (Schmidt et al., 2009).

The researcher followed the scoring procedures outlined by the authors of the survey (Schmidt, et al., 2009-2010, Appendix B). Each item response was scored with a value of one assigned to a response of strongly disagree to a value of five for strongly agree. The quantitative pre- and post-survey data was analyzed using statistical means. Descriptive statistics were generated using SPSS for each of the four TPACK constructs represented on the survey. These descriptive statistics included mean scores, standard deviations, and mean differences from the pre- and post-intervention for each of the four TPACK constructs. Pre- and post-survey statistics were compared to identify and quantify any changes in survey response.

The quantitative data analysis sought to answer the following sub-research questions of the study:

1. How does TPACK-aligned professional development influence in-service teachers' self-assessment of technological knowledge (TK)?
2. How does TPACK-aligned professional development influence in-service teachers' self-assessment of technological pedagogical knowledge (TPK)?
3. How does TPACK-aligned professional development influence in-service teachers' self-assessment of technological content knowledge (TCK)?
4. How does TPACK-aligned professional development influence in-service teachers' self-assessment of technological pedagogical and content knowledge (TPACK)?

Table 5 represents the participant group mean scores for each of the four TPACK framework constructs utilized in this study, and the standard deviation for each using both the pre- and post-intervention survey data. It also illustrates the difference in mean scores between the pre- and post-TPACK survey for each of the four constructs.

Table 5
Group Mean, Standard Deviation, and Mean Differences for Pre- and Post-Intervention TPACK Constructs
(n=9)

TPACK Construct	Pre-Intervention Mean	Std. Deviation	Post-Intervention Mean	Std. Deviation	Mean Difference between Pre- and Post-Intervention
TK	3.00	.58250	3.57	.75911	-0.57
TPK	3.42	.32804	4.27	.52599	-0.85
TCK	2.86	.37731	3.42	.69597	-0.56
TPACK	2.86	.33333	3.30	.62222	-0.44

The pre-intervention group mean for the TK construct was 3.00 on a scale of 1-5 with a standard deviation of .58250. The post-intervention group mean for TK was 3.57 with a standard deviation of .75911. A comparison of the standard deviation suggests that the scores were more varied in the TK construct after the professional development intervention. The data showed a mean difference for TK between the pre- and post-intervention surveys of -0.57. Overall, the participant group did show gains in the TK construct after completion of the professional development intervention.

Participants demonstrated the most gains in the TPK construct. The pre-intervention group mean for TPK was 3.42 on a scale of 1-5 with a standard deviation of .32804. The post-intervention group mean for TPK was 4.27 with a standard deviation of .52599. The pre- and post-intervention standard deviations suggest more variance in the post-intervention scores. The mean difference (-0.85) was the highest of the four TPACK framework constructs. The participant group also appeared to make gains in the TCK construct with a mean difference of -0.56. The pre-intervention group mean was 2.86 with a standard deviation of .37731. The post-intervention group mean was 3.42 with a standard deviation of .69597. Again, the pre- and post-intervention standard deviations suggest more variance in the post-intervention scores.

The final construct analyzed in the framework was TPACK. The participant group made the least gains in this construct, which synthesizes all of the knowledge constructs within the TPACK framework. The mean for TPACK prior to the intervention was 2.86 on a scale of 1-5 with a standard deviation of .37731. The post-intervention mean for the TPACK construct was 3.30 with a standard deviation of .62222. The pre- and post-intervention standard deviations also suggest more variance in the post-intervention scores. The mean difference demonstrated by the TPACK data was -0.44. The participant group did make gains in the TPACK construct; however, those gains were not as high as the TK, TPK, and TCK constructs.

In conclusion, the participant group made gains in all four of the TPACK framework constructs analyzed in this study. The group made the greatest gains in the TPK construct with a mean difference of -0.85 followed by TK (-0.57), TCK (-0.56), and TPACK (-0.44). The group data showed no decrease in the mean scoring of the four TPACK framework constructs (TK, TPK, TCK, and TPACK) following the professional development intervention. However, variability in the scores appeared to be greater in the post-intervention survey data. It should be noted that the standard deviation for the TPK construct scores suggests less variance in scores than do the standard deviations for the other three constructs in both the pre- and post-intervention survey data.

Qualitative data. To provide context for the quantitative data collected via the online pre- and post-TPACK surveys, individual, open-ended virtual interviews were held via the researcher's Zoom link. The first part of the qualitative data analysis involved the transcription of the recorded interviews via an online company, Rev.com, which provided word-for-word transcription from all uploaded audio recordings. The second part of the qualitative data analysis included reading and re-reading the transcripts in order to facilitate total immersion into the

interview data to understand more deeply the information collected. The third part of the qualitative data analysis involved manually coding the data from each transcript. Applying descriptive coding to the data was the first step towards identifying recurring patterns in the data (Creswell, 2012).

The following 10 descriptive codes were identified:

1. Increase in teacher self-efficacy
2. Use of technology to promote student collaboration
3. Choosing technology with content in mind
4. Intentional use of technology to enhance student learning
5. Opportunities to explore Web 2.0 apps
6. Recognition of depth and breadth of technology use
7. Technology to support student choice and student engagement
8. Technology as means to provide more opportunities for application of new learning
9. Technology viewed less as a replacement tool and more as means for transformation
10. Technology is a constraint to teaching and learning when it doesn't work

Part four of the qualitative data analysis involved conducting analytical coding to inform the purpose of the study. Analytical coding occurs when categories or themes are derived from descriptive coding through interpretation and reflection on the meaning of the data (Merriam & Tisdell, 2016). The researcher used an Excel spreadsheet to organize and sort the codes identified in the data sets. The process of analytical coding led to the identification of three overarching themes that emerged from the qualitative data analysis phase: Teacher use of technology to transform teaching and learning, teacher self-efficacy with technology, and barriers to effective technology integration (see Figure 5). The themes were found to overlap in their contextual

support for the quantitative findings in this study. The final part of the qualitative process involved the interpretation of the data as it related to the qualitative research questions.

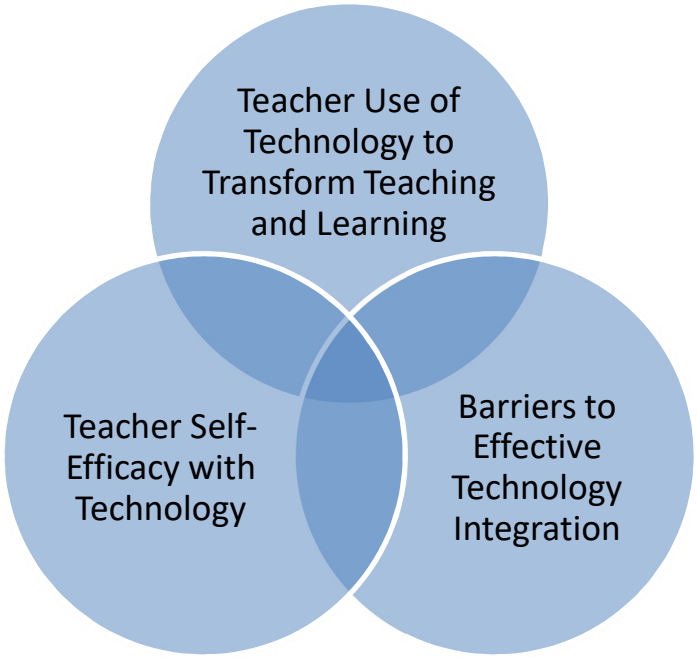

Figure 5 Qualitative research themes: TPACK-aligned professional development and its influence on teacher TPACK.

The qualitative portion of this research study involved organization and analysis of data collected from individual interviews with each of the nine participants in the study. Data from all participants are in narrative and graphic format. All interview participants completed both the pre-and post-intervention TPACK survey and volunteered to participate in the interview as a way to provide context for any changes found in the quantitative portion of the study. In addition to demographic data, participants were asked to respond to questions surrounding effective technology integration, the TPACK framework, personal learning experiences during the professional development intervention, the selection of Web 2.0 technologies for use in course assignments, and any changes in pedagogical approaches as a result of the intervention (see Appendix C). The original 10 descriptive codes identified by the researcher were organized

within the three primary themes: (1) Teacher use of technology for transformational teaching and learning, (2) Teacher self-efficacy with technology use, and (3) Barriers to effective technology integration. The identified descriptive codes were organized within the primary themes as follows:

1. Teacher use of technology for transformational teaching and learning
    a. Use of technology to foster student collaboration
    b. Choosing technology with content in mind
    c. Intentional use of technology to transform pedagogy to enhance student learning
    d. Use of technology to support student choice and student engagement
    e. Technology viewed less as a replacement tool and more as a means for transformation
    f. Technology as means to provide increased opportunities for application of new learning
2. Teacher self-efficacy with technology
    a. Increased self-efficacy
    b. Recognition of depth and breadth of technology use
    c. Opportunities to explore Web 2.0 applications
3. Barriers to effective technology integration
    a. Technology as a constraint to learning when it does not work

Notes were extracted from the interviews and organized according to similar meaning. The meanings were then grouped by themes. Each interview participant was assigned a number that matched the participant number in the quantitative survey portion of this study.

Theme 1: Teacher use of technology for transformational teaching and learning. The initial results of this research focused on how professional development may influence the transformational integration of technology in a K-12, one-to-one mobile device environment. When participants were asked about their understanding of technology integration, the idea that technology should be used in conjunction with content and pedagogical considerations was prevalent. Table 6 shows significant participant responses to the questions, "What does effective technology integration mean to you?" and "Has your understanding of effective technology integration changed at all since your participation in this course?" in relation to this theme.

Table 6
Participant Responses that Indicate Understanding of Transformative Technology Integration and the Professional Development Intervention Course Influence on that Understanding

What does effective technology integration mean to you?	**Has your understanding of effective technology integration changed at all since your participation in this course?**
"It should be a way to enhance understanding and their learning, not just a replacement."	"I think that I understand or can relate to it better."
"….students use (technology) to learn the content and the standards."	"I think the number one takeaway that I had from the course was how to make sure you're thinking about using technology to transform pedagogy. That was not something that I had had at the forefront of my planning for technology as much as I am somebody that loves technology and uses technology…I was never really …purposefully planning to use technology to transform what you were doing."
"I think it means using technology only when it's going to help, and not just using it to use it, and using it in a way that, I think the two biggest things are students' engagement and collaboration."	"It made me feel better in my thinking that I don't always have to use it. I feel like it's kind of pushed on teachers, that you have to use it no matter what…it just made me realize that there are things that you can use technology for that will really help the students to understand and get the content."
"Prior to the course, for me, technology was merely digitizing activities."	"Now I really learned to think about it in a different way and how the technology can

	change the pedagogy and enhance the content delivery."
"Making technology an inherent part of the course, not a little added flavor to it but actually having the course kind of revolve around technology…instead of having students put their hand up or head down so it's secret balloting, I can use technology to eliminate the problem of I don't want to participate, I don't want someone to laugh at me."	"Yeah it changed tremendously since the course…the course introduced me to a lot of tools to use with the students. Having them (students) work with me, and even teach me about some of the technology is very helpful.)
"I always thought just using devices such as a Promethean board for instruction and having kids…either using a laptop or getting on sites to research was the best instruction because they were using technology effectively.	"Since taking this course, I think it's more students choosing ways to demonstrate how they learn things or how they want to show how they've learned."

All participants indicated that their understanding of technology integration had changed since participating in the professional development intervention. Of the six responses detailed in Table 6, all referenced the integration of technology within the context of pedagogy in some way. When asked to summarize any pertinent lessons or learning experiences that occurred during the intervention course, the opportunity to explore different Web 2.0 applications, the use of technology to increase student engagement, and the use of technology to foster collaboration between students and teachers were emphasized by all participants. Participant nine stated, "the first readings or videos we had, the articles mentioned several times not to just to use technology to use it, but to make sure you're integrating it in a way that it really does enhance your lesson. And then also a big thing was making sure the technology that you're integrating works with your pedagogy not against it."

Participants were also asked to reflect on the unit revision they completed as part of the course. As part of that reflection, the researcher asked if they could identify any examples of

TPACK that may lead to student learning. Participant four described her use of technology in the unit as a way to leverage technology to differentiate instruction and personalize learning through student choice. "I tried to look at, as we got later into the course, ways that I could use differentiation and technology together and provide different options to personalize the learning." Participant two integrated blogging into her revised unit and stated, "I just can't wait to use that…just to see kids using their own type of language to demonstrate what they got out of the text." Others discussed technology as a means to increase student engagement and collaboration as it was integrated into their unit revisions. Participant five's response addresses her view of technology integration for transformative teaching and learning:

> In the past, I was just using a PowerPoint when I was teaching a lesson and it wasn't very interactive. And so when I went to revise the lesson, I was thinking about, how can I make this more interactive for the student, as well as having them be able to work with their partners and incorporate more partner work…and also get more out of the actual lesson itself. It's not just me teaching a skill, you practice it and okay, we're done. It's like, how do we see above that? And so I think having them even create their own iMovie was one thing I added in my last lesson revision. And having them be able to take something that I taught and be able to create their own movie, write their own script, act it out. And learning all those things, I think, would be a really powerful tool for them in the end.

This quote describes the teacher's intentional use of technology to transform pedagogy and enhance student learning. The integration of technology in this example fosters student

collaboration, student choice and engagement, and provides means to increase opportunities for application of new learning.

Participants were also asked if their pedagogical approach to teaching had changed since participation in the intervention course. All but one of the nine participants stated that it had. Table 7 illustrates participant responses to that question. Although participant four did not feel her pedagogical approach to teaching had changed, she did indicate that her willingness to try new technology had increased. The remainder of the participant responses suggest an understanding of the shift from technology as an add-on or tool merely to digitize instructional practice to the use of technology to transform pedagogy. There appears to be a continuum of understanding from a willingness to try new technologies in the classroom to intentional use of technology to transform pedagogy, based on participants' responses.

Table 7
Participant Responses to "Has your pedagogical approach to teaching changed since participating in this course? If so, how?"

Participant Number	Response
1	"Yes, it has, because I never included technology. I would use the Promethean Board, but that's me using it. That's me doing it, it's not them doing it."
2	"I would say yes. I'm not just adding technology as fluff."
3	"Oh, definitely. I was stuck in the 80's…the biggest technology I would use..before were dry-erase markers on the board. Where I was and where I am now, it's quantum steps on a continuum. I'm much further than where I was two months ago."
4	"I don't think it's changed as much..but every time I experience and play with new technology I'm more willing to try it myself"
5	"I think for me, it's just really having to incorporate again, open up to the whole thing of using more technology in my classroom. And it has changed my style of teaching because no I am using that. I'm still teaching those skills that the students need, but my way of doing it is just different now."
6	"Oh, definitely. I will definitely be mindful of integrating technology more."

7	"Definitely. I think so. I think that…it's the big shift of going from between digitizing and actually enhancing the content using technology."
8	"I plan for it to change. I haven't actually done any teaching in my classroom since taking the course. But it's in my plans to change it. I really want to make sure I am putting Web 2.0 tools into these learners' hands."
9	"I feel I am more open to trying more technology and looking for resources."

When participants were asked how they decided to use specific technological tools in their unit revisions, many responded that they were intentional about selecting the technology to integrate. Some stated that they selected specific tools for specific purposes; others selected tools based on content considerations, and some selected tools based on pedagogy. For example, several teachers replied that they chose Web 2.0 tools because they wanted to facilitate collaboration and deeper understanding. Others discussed making pedagogical choices in order to personalize and differentiate student learning. Finally, some teachers simply chose a Web 2.0 tool because they had been exposed to it in the course and wanted to try it. Based on the participant responses to this interview question, most seemed to be making decisions about technology integration with content and/or pedagogy in mind.

Theme 2: Teacher self-efficacy with technology. The qualitative interview data indicated self-efficacy with technology as a factor that can impede or constrain a teacher's effective technology integration. Of the nine participants, all discussed their comfort level with technology at some point during the interview. When asked if the meaning of effective technology integration had changed since participation in the intervention course, one teacher described her increased confidence in making decisions about when to use and not to use technology. Another teacher pointed out "really learning to explore different applications" made her more confident. One teacher in particular elaborated on her change. "I have learned so much.

It has opened my eyes; I've learned that I'm the one. I'm fighting me because I am frightened of it, and I'm not good at it, and I need to just push on because this stuff is amazing. When it works, technology is amazing. My eyes are opened. I'm really excited." Still others spoke of their willingness to take more risks with technology because of their participation in the course. Another participant discussed his growing understanding of the depth and breadth of technology that is available. "This course really broadened my horizons, and I think I'll be more effective. I didn't know what I didn't know prior to this course."

Finally, participants spoke to the value of having the time to explore such a wide variety of Web 2.0 applications throughout the intervention course. Instead of asking participants to learn specific technological applications and apply them, the intervention course was designed to support teachers in exploring groups of Web 2.0 applications. Teachers had freedom of choice when it came to applications and were not limited to those shared within the course. When asked if there were any pertinent lessons or learning experiences that occurred for him during the course, one participant responded, "I think it was just nice to have the time to explore more technology tools…when someone says I don't have time to do this, I can't do this, we just stop." The assertion that time can stand in the way of effective technology integration overlaps with Theme 3.

Theme 3: Barriers to effective technology integration. The interview data revealed some recurring concerns that teachers had when discussing their technology integration as a result of the intervention course. The first was the fear of the technology not working or the infrastructure not supporting it. In response to the question, "What does effective technology integration mean to you?" one participant discussed her fear of the technology not working. "I want to do other things…and know that it's okay if it doesn't work." Another teacher, when asked if technology

had precipitated any classroom management issues responded that it was a problem when student-issued devices are cracked or broken. This teacher also pointed out that even when a teacher has planned for effective technology integration, when the infrastructure does not work, it can precipitate classroom management issues as well as a need for an alternate plan. When asked what students need to know in order to use technology effectively, another teacher responded that she has great faith that:

> …they are more comfortable with technology than I am…I think the difference between my students and me is they won't be afraid to experiment. I always have in mind what I want it to do. Then if I can't get it to do it exactly right, I feel I've failed in some way.

In this way, the fear of the technology not working overlaps with the theme of teacher self-efficacy with technology. Another teacher stated in response to whether or not her pedagogical approach to teaching had changed, "…every time I experience and play with new technology I'm more willing to try it myself because there's nothing more frustrating than you plan this big lesson, but all the technology has to work and then it doesn't."

As noted in Theme 2, time to explore a variety of Web 2.0 technological tools can influence a teacher's self-efficacy with technology integration. When that time is not available, it can also serve as a barrier.

Results and Interpretations

When utilizing a mixed-method, single-subject experimental research design, quantitative and qualitative data are analyzed to answer the research questions. The first four research questions address the quantitative portion of this study:

1. How does TPACK-aligned professional development influence in-service teachers' self-assessment of technological knowledge (TK)?
2. How does TPACK-aligned professional development influence in-service teachers' self-assessment of technological pedagogical knowledge (TPK)?
3. How does TPACK-aligned professional development influence in-service teachers' technological content knowledge (TCK)?
4. How does TPACK-aligned professional development influence in-service teachers' self-assessment of technological pedagogical and content knowledge (TPACK)?

The quantitative data analysis provided evidence to address each question. A mixed methods approach allowed the researcher to create context for the quantitative data through the qualitative data gathered. Follow-up interviews were designed to create context and further investigate any change in teachers' self-perceptions of technology integration. The quantitative findings together with the qualitative findings will serve to answer the last two research questions:

5. If teacher self-perception of TPACK has changed at the conclusion of the TPACK-aligned intervention, then what is the perceived context of that change?
6. If teacher self-perception of TPACK has not changed at the conclusion of the TPACK-aligned intervention, then what is the perceived context for the lack of change?

This section will highlight significant results in the research presented to answer all six sub-research questions. This section concludes with the researcher's analysis and synthesis of the six sub-research questions to answer the main research question for this study: How does a TPACK- aligned professional development model for teachers influence teacher self-assessment of TPACK?

Conclusions from Research Questions #1-4

The quantitative data collected during this study suggested that the TPACK-aligned professional development intervention did have a positive influence on participants' technological knowledge (TK), technological pedagogical knowledge (TPK), technological content knowledge (TCK), and technological pedagogical and content knowledge (TPACK) constructs within the TPACK framework. The TPACK-aligned professional development intervention had the most positive influence on participants' TPK. Participants showed the most gains (0.85) in this construct, and the standard deviations around the mean suggested the least variance in individual scores for this construct. The intervention had approximately the same amount of influence on the constructs of TK and TCK with gains of 0.57 and 0.56 respectively. Participants demonstrated the smallest gains in the TPACK construct (0.44), but those gains still reflected a positive influence following the professional development intervention. While gains are reported for each TPACK construct after the professional development intervention, it is important to note that the standard deviations for all construct means were higher after the intervention. This may suggest that the professional development intervention did not have a consistent positive influence on all participants in all construct areas.

Quantitative data summary. The quantitative data analysis and results support the conclusion that the TPACK-aligned professional development intervention, overall, did have a positive influence on the TPACK framework constructs of technological knowledge (TK), technological pedagogical knowledge (TPK), technological content knowledge (TCK), and technological pedagogical and content knowledge (TPACK). While the group data demonstrated increases for each construct, the researcher would be remiss by not illustrating the differences found in the individual pre- and post-assessment means for each of the four TPACK framework

constructs. Table 8 compares the group means, standard deviations and the mean differences for each of the TPACK framework constructs to the percentage of participants who experienced an increase in their self-assessment for each construct. The group mean differences for each construct represent an increase in the group self-assessment mean from the pre- to the post-course intervention survey. Based on the group data alone, the researcher concluded that the TPACK-aligned intervention had a positive influence on all four of the measured TPACK constructs: TK, TPK, TCK, and TPACK. The greatest positive influence is reflected in the group mean difference for TPK (-0.85), the second greatest positive influence can be seen in the group mean difference for TK (-0.57), followed by TCK (-0.56), and finally TPACK (-0.44).

When the group data is examined in context of the individual participant data, the researcher still concluded that the professional development intervention course had the greatest positive influence on the TPACK framework construct of technological pedagogical knowledge (TPK). All participants (100%) reported an increase in their self-assessment of TPK. As seen in Table 8, the other three constructs (TK, TCK, TPACK) did not increase for all participants. Only six participants (66.6%) reported individual gains in TCK, while eight participants (88.9%) reported individual gains in TK and TPACK. The context for these conclusions will be examined in the next section.

Table 8
Group Mean Difference vs. %Increase of Individual Participant Increase in TPACK Self-Assessment (n=9)

TPACK Construct	Pre-Intervention Mean	Std. Deviation	Post-Intervention Mean	Std. Deviation	Mean Difference between Pre- and Post-Intervention	% of participant increase
TK	3.00	.58250	3.57	.75911	-0.57	88.9% (n=8)
TPK	3.42	.32804	4.27	.52599	-0.85	100.0% (n=9)
TCK	2.86	.37731	3.42	.69597	-0.56	66.7% (n=6)
TPACK	2.86	.33333	3.30	.62222	-0.44	88.9% (n=8)

Conclusions from Research Questions #5 and 6

The researcher sought to understand the perceived context for any difference in both individual and group mean TPACK construct scores. The gathering of the qualitative data in this study was designed to provide additional context to the results found in the quantitative data. This section examines the qualitative context of the quantitative findings for each of the four TPACK framework constructs in this study.

Technological knowledge. The post-intervention course interviews revealed that teachers began the course with a wide variety of technological knowledge. The technological knowledge section of the quantitative survey asked questions designed to address teacher self-efficacy with technology. The quantitative data showed an increase for 88.9% (n=8) of the participants' self-assessment of TK at the conclusion of the professional development intervention course. This was further supported by the qualitative data collected during the interview process that indicated an increase in teacher self-efficacy with technological tools, such as Web 2.0 applications. While the course was not designed to provide participants with the skills necessary to utilize specific technological tools, the exposure to a wide variety of Web 2.0 applications together with an expectation for application within the course assignments appears to have supported the increase in teacher self-assessment of TK. Therefore, the data suggested a positive influence on teacher self-assessment of TK as a result of the TPACK-aligned professional development intervention.

Barriers to technology integration was a theme that emerged from the qualitative data. This theme did not provide a great deal of context in which to analyze the quantitative data for TK; nor did it provide context for any change in participant self-assessment of TK. It did overlap with Theme 2, which addressed teacher self-efficacy with technology. Technology integration is

dependent upon teacher efficacy, which is defined as "teachers' judgment about their abilities to promote students' learning" (Hoy & Spero, 2005, p. 343). Teacher preparation programs as experienced by many in-service teachers did not provide for the knowledge and skills necessary to integrate today's technology in the classroom. Therefore, teachers often lack the appropriate experience or skills that come with using technologies for teaching and learning (Koehler, Mishra, & Cain, 2013). Participants in general discussed a fear of the technology not working when attempting to utilize it in the classroom. The researcher included this finding because she believes it does affect teachers' willingness to take risks with technology, and thus may affect their willingness to apply new learning from the professional development intervention to classroom practice.

Technological pedagogical knowledge. The technological pedagogical knowledge section of the survey had the most questions (n=9). The questions were designed to identify teacher self-efficacy for selecting technologies to support a pedagogy that will enhance student learning. This section of the survey also addresses teacher leadership in helping others coordinate the use of technologies and teaching approaches. The quantitative data in this study showed that all participants had increased their TPK at the conclusion of the professional development intervention course. The group mean difference (-0.85) showed an increase in TPK, which represented the most participant gains in the study. Participant responses to the interview question, "Has your pedagogical approach for teaching changed since participating in the course?" elicited a positive response from all nine participants. When participants were asked to elaborate on their response, six of the nine respondents discussed their new understanding of intentionally choosing technology to enhance teaching and learning. Participants referenced readings and videos in the course materials that emphasized the importance of teacher use of

technology for transformational teaching and learning. When asked to reflect on the unit revision designed to provide an opportunity for participants to integrate technology using the new learning from the course, participants in general spoke of their intentionality when choosing Web 2.0 tools. They discussed selecting technology based on a need to differentiate and personalize learning, thus transforming traditional pedagogy. The qualitative data suggests that the content of the professional development intervention supported teacher TPK. This is validated by the increase all nine participants demonstrated in their self-assessment of TPK. Both the qualitative and quantitative data suggest a positive influence on teacher TPK as a result of participation in the TPACK-aligned professional development intervention.

Technological content knowledge. The technological content knowledge (TCK) section of the survey had four questions. The questions addressed teacher self-efficacy for using technology within specific content areas. The quantitative data for this construct demonstrated a mean difference of -0.57 in this study. The individual quantitative data only reflected an increase in TCK self-assessment mean for 66.7% (n=6) of the participants. For two participants, the TCK mean score decreased and for two it remained the same. The two participants whose scores remained the same were both elementary (K-2) teachers. The two participants whose TCK score decreased were secondary teachers, but one was a special education teacher who pushes into various classrooms and the other was a school counselor. There were no specific TCK questions on the survey that related to special education in general or school counseling. There were specific questions to address the use of technologies for mathematics, literacy, science, and social studies. The course did not contain any new learning relative to specific content areas, but rather it did pair participants with others in similar content areas. Because the participants were a convenience sample, an exact match for all participants was not possible.

This could have had some bearing on those who self-assessed their TCK lower at the conclusion of the professional development intervention. The study did find that the qualitative responses included in the categories under Theme 1 (Teacher Use of Technology to Transform Teaching and Learning) reflected content considerations when discussing why those chose particular technologies to integrate in their revised units of study. One conclusion that can be drawn from this analysis is that perhaps the professional development course should address more technologies that support specific content area teaching and learning. Within the context of the qualitative data, the quantitative data did appear to support an increase in the participant group TCK. Therefore, the TPACK-aligned professional development course did suggest a positive influence on teacher self-assessment of TCK.

Technological pedagogical and content knowledge. The technological pedagogical and content knowledge (TPACK) section of the survey contained four questions. The questions were designed to elicit responses regarding teacher self-efficacy with pedagogy, content, and technology. Individual quantitative data showed an increase in TPACK self-assessment for 88.9% (n=8) of the study participants. The group mean difference (-0.44) reflected modest participant gains in the TPACK construct. The sub-themes found in the qualitative data support these findings. In response to the interview questions, participants discussed their use of technology to promote student collaboration, choosing technology with content and learning goals in mind, and the intentional use of technology to transform pedagogy and enhance student learning. Participants also discussed the value they found in the opportunities to explore Web 2.0 applications within the course. The integration of technology to support student choice and student engagement, and the shift from using technology as a replacement tool to technology as a means for transformation, were common findings within the qualitative data. Within this context,

the researcher concluded that the TPACK-aligned professional development had a positive impact on teacher self-assessment of TPACK.

Qualitative summary. The qualitative research data provided context for the change in teacher self-assessment for all four of the TPACK framework constructs (TK, TPK, TCK, and TPACK). The positive influence on teacher TK, TPK, TCK and TPACK that the professional development intervention had based on the group self-assessment data is better understood in the context of the qualitative data. Participants found that the intervention course increased their self-efficacy for technology integration and that self-efficacy empowered them to take more risks with technology in the classroom. More notable, were the responses that discussed teacher use of technology for transformational teaching and learning. Key understandings from the course included the use of technology for student collaboration, selecting technology with content in mind, the intentional use of technology to transform pedagogy in order to enhance student learning, technology as a means to support student choice and increase student engagement, and technology as a means to provide opportunities for application of new learning. Participants were also found to view technology less as a replacement tool and more as a means for transformation of teaching and learning.

Summary

This chapter discussed the findings of this mixed methods, single-subject, experimental research study. The quantitative portion of this study was designed to answer four research questions focused on the influence a TPACK-aligned professional development model may have on in-service teacher self-assessment of four constructs within the TPACK framework: TK, TPK, TCK, and TPACK. The researcher implemented key features of quantitative, single-subject, experimental design:

1. *Intervention research.* The use of a quantitative experimental design with a planned intervention.
2. *Intraparticipant research.* Each study participant serves as his or her own control, so all participants are exposed to the intervention.
3. *Baseline phase.* Participants are observed in a baseline condition without the stimulus of intervention.
4. *Intervention phase.* The researcher introduces an intervention condition and again monitors the behavior of the participants. The intervention is considered the independent variable in the study.
5. *Analysis of the data.* The researcher compiles the results as to whether the behavior changed from the baseline phase to the intervention phase. (Creswell, 2015, p. 317)

Quantitative data were gathered during the baseline phase of this study and again following the six-week professional development intervention. Findings from the quantitative data analysis indicated that the TPACK-aligned professional development intervention resulted in participant gains in all of the TPACK constructs identified in this study. The highest gains (0.85) were found in the TPK construct, followed by TK (0.57), TCK (0.56), and finally TPACK (0.44). Findings from a comparison of the individual quantitative data to the group quantitative data suggested that there were some differences in the influence of the professional development intervention on the group compared to the influence of the professional development on each individual. While the professional development intervention resulted in an increase in group mean scores in each of the four constructs (TK, TPK, TCK, and TPACK), the individual data did not find an increase in every construct for every participant. This finding could account for the higher standard deviations around the post-intervention means for the participant group.

Technological pedagogical knowledge (TPK) was the only construct for which all nine participants reported an increase in their mean self-assessment score at the conclusion of the professional development intervention.

Qualitative data were gathered only at the conclusion of the intervention phase of this research study. The qualitative portion of this study was designed to answer two research questions that focused on providing context for a change in teacher self-assessment of TPACK or a lack of change in teacher self-assessment of TPACK. All nine participants provided responses to interview questions designed to understand the context of the quantitative findings. Individual participant responses were organized into three themes: teacher use of technology to transform teaching and learning, teacher self-efficacy with technology, and barriers to technology integration. Within each theme was at least one descriptive code, or sub-theme. Interview responses that fell under the themes of teacher use of technology to transform teaching and learning and teacher self-efficacy with technology provided the most context for the quantitative data. Overall, the qualitative data supported the findings from the quantitative data. Sub-themes supported the positive influence on teacher TK, TPK, TCK, and TPACK reported at the conclusion of the professional development intervention. In general, participants reported an increase in understanding for the following sub-themes:

1. Use of technology to foster student collaboration.
2. Choosing technology with content in mind.
3. Intentional use of technology to transform pedagogy to enhance student learning.
4. Use of technology to support student choice and student engagement.
5. Technology viewed less as a replacement tool and more as a means for transformation.

6. Technology as means to provide increased opportunities for application of new learning.

Teacher self-efficacy with technology was also found to be a recurring theme. Qualitative findings reported an increase in teacher self-efficacy with the overall integration of technology in their classrooms. The qualitative data also revealed that the professional development intervention provided participants with a better understanding of the depth and breadth with which technology can be utilized in the classroom. Participants emphasized the value of having time to explore the vast number of Web 2.0 applications that are available. The third theme found in the qualitative data was barriers to technology integration. This theme did not provide a great deal of context in which to analyze the quantitative data; nor did it provide context for any change in participant self-assessment of the TPACK framework constructs at the conclusion of the professional development intervention. It did overlap with theme two, which addressed teacher self-efficacy with technology. Participants in general discussed a fear of the technology not working when attempting to utilize it in the classroom. The researcher believes that this finding could affect teachers' willingness to take risks with technology, which may also affect their willingness to apply new learning from the professional development intervention to their practice in the classroom.

This study was designed to answer one central research question: How does a TPACK-aligned professional development model for teachers influence teacher self-assessment of TPACK? Both the quantitative and the qualitative findings from this mixed-methods, single-subject, experimental research study suggest that a TPACK-aligned professional development model can have a positive influence on teacher self-assessment of TPACK.

Chapter 5: Conclusions and Recommendations

Introduction

Emerging expectations for teachers include being adept at a variety of technology-based content delivery, using digital strategies in their work with students, providing student-centered learning experiences, and using technology to encourage students to engage in learning beyond the four walls of the classroom and the school day (Johnson, Becker, Estrada & Freeman, 2014). Educational leaders are tasked with providing professional development that results in integrating technology for learning versus the use of technology in isolation. However, professional development designed for technology integration is typically skill-based and frequently neglects the differentiated contexts of content and pedagogy in which teachers operate (Koehler, Mishra, & Cain, 2013). In order to influence student performance, teachers need to implement new pedagogical practices that are acquired through professional development (Lawless & Pellegrino, 2007).

This research study was designed to examine the influence of a TPACK-aligned professional development intervention of teacher self-assessment of four of the constructs within the TPACK framework: technological knowledge (TK), technological pedagogical knowledge (TPK), technological content knowledge (TCK), and technological pedagogical and content knowledge (TPACK). This mixed methods, single-subject, experimental study employed a pre- and post-quantitative online survey that was administered prior to and at the conclusion of an online, asynchronous professional development intervention. The professional development intervention was designed by the researcher to align to the TPACK framework. Nine participants representing a convenience sample taken from a 196 faculty at a K-12 public school district participated in the professional development intervention. All nine study participants also

completed an online, virtual interview with the researcher. The interview was designed to provide context for any change, or lack of change, in participant self-assessment of the TPACK constructs at the conclusion of the professional development intervention.

Prior research in the area of TPACK has helped educators to understand the inter-relationships between technology, pedagogy, and content (Chai, Koh, & Tsai, 2013; DiBlas, Fiore, Mainett, Vergallo, & Paolini, 2014; Harris, Mishra, & Koehler, 2009). This understanding could provide a foundation for professional learning that results in transformative technology integration. This chapter builds on the findings, results, and interpretations presented in Chapter 4 by offering conclusions to the research questions and concludes with recommendations for possible solutions and future research.

Conclusions

The main purpose of this study was to provide additional research evidence on whether TPACK-aligned professional development models are effective in preparing in-service teachers to leverage technology in a manner that transforms teaching and learning. In order to inform a foundation for professional learning that results in transformative technology integration, the researcher sought to answer one central research question: How does a TPACK- aligned professional development model for teachers influence teacher self-assessment of TPACK? This study answered this question by addressing the following sub-questions.

Sub-questions:

1. How does TPACK-aligned professional development influence in-service teachers' self-assessment of technological knowledge (TK)?
2. How does TPACK-aligned professional development influence in-service teachers' self-assessment of technological pedagogical knowledge (TPK)?

3. How does TPACK-aligned professional development influence in-service teachers' self-assessment of technological content knowledge (TCK)?
4. How does TPACK-aligned professional development influence in-service teachers' self-assessment of technological pedagogical and content knowledge (TPACK)?
5. If teacher self-assessment of TPACK has changed at the conclusion of the TPACK-aligned intervention, then what is the perceived context of that change?
6. If teacher self-assessment of TPACK has not changed at the conclusion of the TPACK-aligned intervention, then what is the perceived context for the lack of change?

After reviewing and analyzing the quantitative and qualitative data from the study, the following conclusions were made:

1. TPACK-aligned professional development can have a positive influence on in-service teachers' technological knowledge (TK). The participant group made gains in the self-assessment of TK after the professional development intervention, and the qualitative data showed evidence of increased self-efficacy with technology integration that supports those gains.
2. TPACK-aligned professional development can have a positive influence on in-service teacher's technological content knowledge (TCK). The participant group made gains in the self-assessment of TCK after the professional development intervention. The qualitative data supported those gains with evidence of teacher's intentional choosing of technology to support content learning.
3. TPACK-aligned professional development can have a positive influence on in-service teachers' technological pedagogical knowledge (TPK). The participant group made the highest gains in this construct, and each participant reported an increase in self-

assessment of TPK after the professional development intervention. This construct demonstrated the lowest standard deviation around the group mean, suggesting that the intervention may have had the most consistent influence on the group. However, it should be noted that the group demonstrated the highest mean score in TPK self-assessment prior to the intervention, which suggests a stronger knowledge base for the group in this construct prior to the intervention. Because the group appeared to have more background knowledge in this construct, this could have supported the higher gains for TPK. In addition, TPK was emphasized in each module in the professional development course, so the course design could have also influenced the greater gains in this construct. Qualitative data analysis confirmed that teachers were being intentional throughout the course in selecting technological tools in a manner that would enhance and transform teaching and learning.

4. TPACK-aligned professional development can have a positive influence on in-service teachers' technological pedagogical and content knowledge (TPACK). This is the construct that synthesizes the other six TPACK framework constructs: technological knowledge, pedagogical knowledge, content knowledge, pedagogical content knowledge, technological pedagogical knowledge and technological content knowledge. The participant group made the lowest gains in this construct. Qualitative data describing teacher use of technology to support pedagogy, content and enhance student learning supported these gains. Participants also reported a shift from using technology as a replacement tool to using technology to transform student learning. Perhaps a change in the intervention course design is warranted to increase the gains in the TPACK construct.

Recommendations

Based on the findings, results, and conclusions of this study, the researcher offers the following recommendations for administrators planning for educational technology professional development within one-to-one, or increased mobile device settings K-12. The researcher also offers recommendations for further study to support both the design of educational technology professional development and the effective integration of technology that results in transformation of teaching and learning. These recommendations provide suggestions for meeting the 2017 ISTE standards. The 2017 ISTE standards ask teachers to approach educational technology integration as both a facilitator and designer of student learning to "foster a culture where students take ownership of their leaning goals and outcomes in both independent and group settings," and to "use technology to create, adapt and personalize learning experiences that foster independent learning and accommodate learner differences and needs" (p. 2).

Recommendations for K-12 Administrators

Administrators who are embarking on one-to-one device initiatives, or those who are increasing access to mobile device technology, should allot adequate time for educational technology professional development. Research indicates that it takes 30 hours of professional development to change teacher practice (Harris, 2008). The TPACK-aligned professional development intervention in this study was designed as a six-week, course with 45 hours of on-line learning. Most professional development in K-12 public school districts is much less than that, and administrators have myriad initiatives to address in a small amount of time. Teachers and administrators cannot expect educational technology professional development to result in technology integration that transforms teaching and learning unless adequate time is provided for professional learning.

Administrators planning for educational technology professional development should also examine the design of the professional development. School leaders who implement one-to-one technology initiatives often focus only on technological skills when designing professional development. This results in technology use that is an "add-on" versus the integration of digital tools with content and pedagogy to transform student learning and foster achievement. Research shows that most technology integration efforts lack an intentional connection between instructional strategies, technological skills, and the classroom context or content of study (Hew & Brush, 2007). Educators need to consider the inter-relationships between technology, pedagogy and content when integrating technology within a changing classroom environment. When designing professional development for technology integration, TPACK should be a consideration. This research study suggests that TPACK-aligned professional development could result in better understandings of the inter-relationships between technology, pedagogy and content when integrating technology in the classroom, thus resulting in the transformational integration of technology.

Recommendations for Further Study

The findings presented in this study provide additional research evidence on the design of educational technology professional development (ETPD) that results in technology integration to transform teaching and learning. This study provides evaluation data that speaks to the impact of ETPD on pedagogical change and student learning. Findings in this study are similar to those in a study done by Anderson (2012). In an attempt to address gaps in the literature that evaluate the effectiveness of ETPD, Anderson (2012) conducted a quantitative, pretest-posttest design study. The study addressed the effectiveness of professional development for integrating technology in the curriculum of an urban Iowa middle school. Participants in this study also used

a TPACK survey to assess their technological knowledge (TK), technological and pedagogical knowledge (TPK) and technological pedagogical and content knowledge (TPACK) (Anderson, 2012). The TPACK framework was also the basis for the professional development provided as the intervention in Anderson's (2012) study. Results of Anderson's study suggested a positive correlation between the professional development intervention and the middle school teachers' TPACK in all constructs (Anderson, 2012). Anderson's (2012) study was limited to middle school teachers. This study was limited to nine, K-12 teachers of various grade levels and content areas. The findings of this research study contribute to the literature on the TPACK framework and its basis for in-service teacher ETPD. Further study is recommended to continue to address the gaps in the literature that evaluate the effectiveness of ETPD for in-service teachers and to determine correlation between TPACK-aligned professional development and transformational integration of educational technology.

A larger study of in-service teachers representing all grade levels and content areas is recommended to determine correlation. Without such a follow-up study, the researcher cautions against generalizing the results of this research study to all in-service teachers due to the small sample size. Additional research is recommended to identify the optimum design of professional development for transformational technology integration. This study examined only one ETPD design and can only suggest the influence of TPACK-aligned ETPD on teachers' pedagogical change and student learning. The findings in this study suggest that the use of the TPACK framework to design ETPD may result in technology integration that transforms teacher pedagogy and student learning.

In addition to conducting a larger study to determine correlation between TPACK-aligned ETPD and the transformation of teaching and learning, the researcher recommends

studying the student perspective of educational technology integration in the classroom and its impact on learning. The researcher also recommends observing teacher and student practice in the classroom to identify which components of the TPACK-aligned technological professional development are applied. Such observation could inform the degree to which the ETPD transforms teaching and learning.

Summary

The purpose of this research study was to provide additional evidence on whether TPACK-aligned professional development models are effective in preparing in-service teachers to leverage technology in a manner that transforms teaching and learning. The findings of this study provide additional research evidence that suggestsTPACK-aligned professional development models may be effective in preparing in-service teachers to leverage technology in a manner that transforms teaching and learning. This mixed methods, single-subject, experimental research study suggests that a TPACK-aligned professional development intervention can result in gains for teacher self-assessment of technological knowledge (TK), technological pedagogical knowledge (TPK), technological content knowledge (TCK), and technological pedagogical content knowledge (TPACK). However, due to the small sample size of this study, the researcher cautions against any generalization of the findings. Overall, the findings of the study suggest that TPACK-aligned professional development may have a positive influence on K-12 in-service teachers' TPACK. Recommendations for administrators provide potential solutions to help advance K-12 professional development for effective technology integration in K-12 public school settings. These findings also provide a basis for further TPACK-related research in the design of educational technology professional development.

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APPENDIX A: Professional Development Intervention Course Outline

Teaching and Learning in the 21st Century Classroom

Instructors: Elena M. Tachau

Target Audience: K-12 classroom teachers

45 hours of online learning

Instructional Dates and Times: July 10-August 18, 2017
6 week, asynchronous online course

Course Description:
This course examines the basis for educational change in the 21st Century. Students will be exposed to 21st Century pedagogies with a focus on the TPACK framework for transformational integration of technology. This course is designed for the teacher who wants to design, develop and facilitate experiences for students that meet the needs of the 21st Century learner. Participants will be exposed to a variety of technological tools. They will use those tools together with the TPACK framework, an understanding of Creativity and Innovation, Blended Learning, Personalized Learning, Project-Based Learning, and Problem-Based Learning to collaborate with teachers in the same grade level or content area on adapting and revising lessons and units of instruction.

Note: There is no device provided with this course. All participants will need to supply their own device in order to access the course via Schoology. While this course is entirely online, it is not self-paced. Assignments will be due on a weekly basis, and participants will be expected to attend virtual class meetings and virtually collaborate with other members of the course.

Learning Goals

- To use knowledge of subject matter, pedagogy, and technology to facilitate experiences that advance student learning, creativity, and innovation. (ISTE Standards for Teachers, 1)
- To design, develop, and evaluate authentic learning experiences and assessments that incorporate contemporary tools and resources to maximize content learning. (ISTE Standards for Teachers, 2)
- To collaborate with peers using digital tools and resources to support student success and innovation. (ISTE Standards for Teachers, 3)

Course Outline:

Module 1: TPACK
Essential Question: What is TPACK and how can it guide educators in transformational integration of technology?

Module 2: Creativity and Innovation
Essential Question: How can teachers use technology to create innovative learning experiences in the 21st Century Classroom?

Module 3: Blended Learning
Essential Question: How does Blended Learning transform pedagogy in the 21st Century Classroom?

Module 4: Personalized Learning
Essential Question: How does Personalized Learning transform pedagogy in the 21st Century Classroom?

Module 5: Project Based Learning and Problem Based Learning
Essential Question: How do Project Based Learning and Problem Based Learning transform pedagogy in the 21st Century Classroom?

Module 6: Your 21st Century Classroom
Essential Question: How will your classroom meet the needs of 21st Century students?

APPENDIX B: Survey to be Replicated in this Study

Survey of Preservice Teachers' Knowledge of Teaching and Technology

Denise A. Schmidt, Evrim Baran, and Ann D. Thompson
Center for Technology in Learning and Teaching
Iowa State University

Matthew J. Koehler, Punya Mishra, and Tae Shin
Michigan State University

Usage Terms: Researchers are free to use the TPACK survey, provided they contact Dr. Denise Schmidt (dschmidt@iastate.edu) with a description of their intended usage (research questions, population, etc.), and the site locations for their research. The goal is to maintain a database of how the survey is being used, and keep track of any translations of the survey that exist.

Version 1.1: (updated September 1, 2009). This survey was revised to reflect research results obtained from its administration during the 2008-2009 and 2009-2010 academic years. This document provides the latest version of the survey and reports the reliability scores for each TPACK domain. (This document will be updated as the survey is further developed).

The following papers and presentations highlight the development process of this survey:

Schmidt, D. A., Baran, E., Thompson A. D., Koehler, M. J., Mishra, P. & Shin, T. (2009-10). Technological Pedagogical Content Knowledge (TPACK): The Development and Validation of an Assessment Instrument for Preservice Teachers. *Journal of Research on Technology in Education, 42*(2), 123-149.

Schmidt, D. A., Baran, E., Thompson A. D., Koehler, M. J., Mishra, P. & Shin, T. (2009). The Continuing Development, Validation and Implementation of a TPACK Assessment Instrument for Preservice Teachers. Paper submitted to the 2010 Annual Meeting of the American Educational Research Association. April 30-May 4, Denver, CO.

Schmidt, D., Baran, E., Thompson, A., Koehler, M.J., Shin, T, & Mishra, P. (2009, April). *Technological Pedagogical Content Knowledge (TPACK): The Development and Validation of an Assessment Instrument for Preservice Teachers.* Paper presented at the 2009 Annual Meeting of the American Educational Research Association. April 13-17, San Diego, CA.

Schmidt, D., Baran, E., Thompson, A., Koehler, M.J., Mishra, P., & Shin, T. (2009, March). *Examining preservice teachers' development of technological pedagogical content knowledge in an introductory instructional technology course.* Paper presented at the 2009 International Conference of the Society for the Information and Technology & Teacher Education. March 2-6, Charleston, SC.

Shin, T., Koehler, M.J., Mishra, P. Schmidt, D., Baran, E., & Thompson, A., (2009, March). Changing technological pedagogical content knowledge (TPACK) through course experiences. Paper presented at the 2009 International Conference of the Society for the Information and Technology & Teacher Education. March 2-6, Charleston, SC.

How do I use the survey? The questions you want are most likely questions 1-46 starting under the header “TK (Technology Knowledge)”. In the papers cited above, these categories were removed so that participants were not oriented to the constructs when answering the survey questions. The items were presented in order from 1 through 46, however. The other items are more particular to individual study and teacher education context to better understand results found on questions 1-46. You are free to use them, or modify them. However, they are not the core items used to measure the components of TPACK.

How do I score the survey? Each item response is scored with a value of 1 assigned to strongly disagree, all the way to 5 for strongly agree. For each construct, the participant’s responses are averaged. For example, the 6 questions under TK (Technology Knowledge) are averaged to produce one TK (Technology Knowledge) Score.

Reliability of the Scores (from Schmidt et al, 2009).

TPACK Doman	**Internal Consistency (alpha)**
Technology Knowledge (TK)	.86
Content Knowledge (CK)	
Social Studies	.82
Mathematics	.83
Science	.78
Literacy	.83
Pedagogy Knowledge (PK)	.87
Pedagogical Content Knowledge (PCK)	.87
Technological Pedagogical Knowledge (TPK)	.93
Technological Content Knowledge (TCK)	.86
Technological Pedagogical Content Knowledge (TPACK)	.89

Thank you for taking time to complete this questionnaire. Please answer each question to the best of your knowledge. Your thoughtfulness and candid responses will be greatly appreciated. Your individual name or identification number will not at any time be associated with your responses. Your responses will be kept completely confidential and will not influence your course grade.

DEMOGRAPHIC INFORMATION

1. Gender
    a. Female
    b. Male

2. Age range
    a. 18-22
    b. 23-26
    c. 27-32
    d. 32+

3. Area of Specialization
    a. Art
    b. Early Childhood Education Unified with Special Education
    c. English and Language Arts
    d. Foreign Language
    e. Health
    f. History
    g. Instructional Strategist: Mild/Moderate (K8) Endorsement
    h. Mathematics
    i. Music
    j. Science-Basic
    k. Social Studies
    l. Speech/Theater
    m. Other

4. Years in Teaching
    a. 0-5
    b. 6-12
    c. 13-20
    d. 20+

Technology is a broad concept that can mean a lot of different things. For the purpose of this questionnaire, technology is referring to digital technology/technologies. That is, the digital tools we use such as computers, laptops, iPods, handhelds, interactive whiteboards, software programs, etc. Please answer all of the questions and if you are uncertain of or neutral about your response you may always select "Neither Agree or Disagree"

	Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree
TK (Technology Knowledge)					
1. I know how to solve my own technical problems.					
2. I can learn technology easily.					
3. I keep up with important new technologies.					
4. I frequently play around the technology.					
5. I know about a lot of different technologies.					
6. I have the technical skills I need to use technology.					
CK (Content Knowledge)					
Mathematics					
7. I have sufficient knowledge about mathematics.					
8. I can use a mathematical way of thinking.					
9. I have various ways and strategies of developing my understanding of mathematics.					
Social Studies					
10. I have sufficient knowledge about social studies.					
11. I can use a historical way of thinking.					
12. I have various ways and strategies of developing my understanding of social studies.					
Science					
13. I have sufficient knowledge about science.					
14. I can use a scientific way of thinking.					
15. I have various ways and strategies of developing my understanding of science.					
Literacy					
16. I have sufficient knowledge about literacy.					
17. I can use a literary way of thinking.					
18. I have various ways and strategies of developing my understanding of literacy.					

PK (Pedagogical Knowledge)					
19. I know how to assess student performance in a classroom.					
20. I can adapt my teaching based-upon what students currently understand or do not understand.					
21. I can adapt my teaching style to different learners.					
22. I can assess student learning in multiple ways.					
23. I can use a wide range of teaching approaches in a classroom setting.					
24. I am familiar with common student understandings and misconceptions.					
25. I know how to organize and maintain classroom management.					

PCK (Pedagogical Content Knowledge)					
26. I can select effective teaching approaches to guide student thinking and learning in mathematics.					
27. I can select effective teaching approaches to guide student thinking and learning in literacy.					
28. I can select effective teaching approaches to guide student thinking and learning in science.					
29. I can select effective teaching approaches to guide student thinking and learning in social studies.					
TCK (Technological Content Knowledge)					
30. I know about technologies that I can use for understanding and doing mathematics.					
31. I know about technologies that I can use for understanding and doing literacy.					
32. I know about technologies that I can use for understanding and doing science.					
33. I know about technologies that I can use for understanding and doing social studies.					

TPK (Technological Pedagogical Knowledge)					
34. I can choose technologies that enhance the teaching approaches for a lesson.					
35. I can choose technologies that enhance students' learning for a lesson.					
36. My teacher education program has caused me to think more deeply about how technology could influence the teaching approaches I use in my classroom.					
37. I am thinking critically about how to use technology in my classroom.					
38. I can adapt the use of the technologies that I am learning about to different teaching activities.					
39. I can select technologies to use in my classroom that enhance what I teach, how I teach and what students learn.					
40. I can use strategies that combine content, technologies and teaching approaches that I learned about in my coursework in my classroom.					
41. I can provide leadership in helping others to coordinate the use of content, technologies and teaching approaches at my school and/or district.					
42. I can choose technologies that enhance the content for a lesson.					

TPACK (Technology Pedagogy and Content Knowledge)					
43. I can teach lessons that appropriately combine mathematics, technologies and teaching approaches.					
44. I can teach lessons that appropriately combine literacy, technologies and teaching approaches.					
45. I can teach lessons that appropriately combine science, technologies and teaching approaches.					
46. I can teach lessons that appropriately combine social studies, technologies and teaching approaches.					

APPENDIX C: Post-Intervention Interview Protocol

Research Questions:

Qualitative Questions:

1. If teacher self-perception of TPACK has changed at the conclusion of the TPACK-aligned intervention, then what is the perceived context for that change?
2. If teacher self-perception of TPACK has not changed at the conclusion of the TPACK-aligned intervention, that what is the perceived context for the lack of change?

Interview Questions: *Source:* The Practitioner's Guide to TPACK, 2012

1. How many years have you taught? In what roles (grade level, subject area)? At this school?
2. Have you received any awards or special recognition for your teaching?
3. How do students best learn (insert subject area) content?
4. What does effective (insert subject area) teaching look like in your opinion?
5. What does effective technology integration mean to you?
    a. Has this meaning changed at all since your participation in PD Course?
6. Summarize any pertinent lessons or learning experiences that occurred during the PD Course.
7. When you look back over the lesson you revised, what are some examples of TPACK that you believe will lead to student learning?
8. How did you decide to use a resource like (insert technology or Web 2.0 tool)
9. What do students need to know in order to effectively use (insert technology or Web 2.0 tool)?

10. How does (insert technology) align with your pedagogical approach for teaching (insert subject area)?
11. Has your pedagogical approach for teaching changed since participating in this course? If so, how?
12. How did you help students learn these concepts in previous years, before using the (insert technology)?
13. What will be your strongest evidence that the students met the learning objective for the lesson?
14. Did the technology precipitate any classroom management issues prior to this course? If so, how did you deal with them? Do you anticipate the same issues when you teach the revised lesson? Why or why not?
15. How might your approach to planning for the learning of (insert subject area) with technology be different now? In what ways will it stay the same?

APPENDIX D: Participant Consent Form

Dear Participant:

By signing this consent form, you are agreeing to participate in a research study being conducted by Elena Tachau, the principal investigator. The purpose of this research study is to investigate the relationship between a technological, pedagogical, and content knowledge (TPACK)-aligned professional development intervention and transformative technology integration. Your participation in this study will include responding to a 46-question survey prior to beginning the course, *Teaching and Learning in the 21st Century,* and you will be asked to complete the same survey once the six-week course has concluded.

Results of this study will be used in a dissertation as part of Drexel University's doctorate of education program. Please understand that your participation is completely voluntary and you are free to withdraw at any time. Please do not hesitate to ask me any questions you may have about this study.

There are no known risks and/or discomforts associated with this study and your name will not be associated with any research findings. All survey responses will be anonymous and will not be used in any way for evaluative purposes in this course or in evaluation of your performance as a professional in the school district. The expected benefits associated with your participation are to help the district design more effective professional development for technology integration and assist in determining if the design of the professional development does indeed transform teaching and learning in order to increase student achievement.

By signing below, you agree to complete the survey protocol associated with this study for the purposes described above.

_____
NAME (print)

_____
NAME (sign)

_____
DATE

APPENDIX E: *Teaching and Learning in the 21st Century* Course Final Project Rubric

	1. Accomplished	2. Developing	3. Beginning
Use of technology transforms pedagogy: Technology is integrated as a tool to extend, collaborate, and/or personalize learning. Without it, the pedagogy would change.			
Technology use is integrated to maximize content learning. : Tech tools are chosen because they best support and can maximize the content you are teaching.			
Innovation/Creativity: Technology is used to create innovative and/or creative learning experiences.			
Blended Learning: Some aspect of blended learning is used to transform pedagogy within the unit.			
Personalized Learning: Technology is used to personalize learning via multiple means of representation, multiple means of engagement, and/or multiple means of action and expression.			
Project Based/Problem Based Learning: Project based or problem based learning is integrated in the unit to transform pedagogy and deepen understanding and application of content.			
Learning Goals: Learning Goals are clearly articulated and the use of technology supports student achievement as aligned with the learning goals.			